AS GOOD AS DOCTORS?: TASK-SHIFTING PRIMARY CARE TO NON-PHYSICIAN CLINICIANS IN NIGERIA.

by
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Abstract

Background: A world-wide human resources for health crisis has stimulated a call for further investment in human resource training and a search for alternative health service delivery models to fill large existing service delivery gaps. The overall lack of trained health workers and difficulties in posting and retaining highly trained health workers in rural areas for the provision of primary health care, has led a number of countries to pragmatically shift their attention to the creation of new, or the strengthening of existing, non-physician clinician programs. In the 1970's Nigeria created a non-physician clinician cadre of community health extension workers who together with nurses, has come to provide the bulk of the public primary health services in the country. Last year, with the Nigerian Federal Government's new task-shifting strategy, the responsibilities for provision of primary care by these non-physician clinicians has been expanded and more clearly defined. Little is known, however, about the knowledge that these cadres have regarding the provision of primary care, especially as compared to physicians. The overall aim of this dissertation was to estimate the differences in knowledge of clinical guidelines for the overall delivery of primary care (paper 1) and specifically, the treatment of childhood pneumonia (paper 2) and screening of type II Diabetes (paper 3), between non-physician clinicians and medical officers in Nigeria. We defined non-physician clinicians as Community Health Officers (CHOs), Nurse Officers, Nurse Midwives, Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs).

Methods: We used data collected by the World Bank's Service Delivery Indicator Survey from 12 Nigerian states in 2013. The survey interviewed a total of 5,192 health workers from 2,480 health facilities using clinical vignettes to assess their knowledge for the consultation of five

hypothetical cases: (1) of a child presenting with diarrhea, (2) a child with pneumonia, (3) an adult with type II Diabetes, (4) an adult with Tuberculosis and (5) a child with malaria. For paper 1, using the Nigerian Standing Orders (clinical guidelines) we created aggregate variables for (i) the knowledge of consultation process guidelines, (ii) diagnostic accuracy and (iii) knowledge of treatment guidelines for each health worker across the five cases as indicators of overall primary care knowledge. We used facility-level fixed-effects regression models with controls for health worker characteristics for each of our aggregate variables to estimate differences in knowledge between Medical Officers and non-physician clinician cadres. For paper 2, we focused our attention on the differences between Medical Officer and non-physician clinician knowledge of the treatment guidelines for a case of pneumonia. We used facility-level fixed effect logistic regression models with controls for health worker characteristics to estimate differences in knowledge of each treatment component as well as the provision of a full treatment. For paper 3, we focused on the differences in knowledge between Medical Officers and non-physician clinician cadres for the screening of a case of type II diabetes. We used facility-level fixed effects logistic regression model with controls for health worker characteristics to estimate the differences in knowledge of the clinical guidelines for screening and the diagnostic accuracy between these cadres.

Results: Across our three papers we found low overall health worker knowledge of clinical guidelines for consultation, diagnosis and treatment. Results from Paper 1 point to small, albeit significant differences in the knowledge of consultation process clinical guidelines between Medical Officers and non-physician clinician cadres, significant differences in diagnostic accuracy for CHEWs and JCHEWs but not other cadres, and no significant differences in knowledge of treatment guidelines between these cadres. With analyses from Paper 2, we find that although Medical Officers have significantly greater knowledge of the consultation process guidelines and are better able to identify a case of pneumonia; they are equally or less likely to

know to prescribe the full treatment to a child with this illness than are non-physician clinicians. Our findings suggest that non-physician clinicians compare favorably with Medical Officers in their knowledge to prescribe recommended or effective antibiotics, equally or more likely to know to recommend paracetamol and more likely to know to recommend follow-up, as are Medical Officers, when treating a childhood case of pneumonia. In Paper 3 we find that Medical Officers are more likely to know the clinical guidelines for the screening of a patient with type II Diabetes when compared to CHOs, CHEWs and JCHEWs but not Nurse Officers or Nurse Midwives. Although Medical Officers have greater knowledge of the guidelines, they are not more accurate in their identification of a hypothetical type II Diabetes case than are all non-physician clinician cadres except for JCHEWs. Our overall analyses suggest no differences in the effects of gender nor experience on health worker knowledge but, point to significantly greater differences in the knowledge of health workers who ask more non-essential questions during the vignettes interviews than those who do not.

Conclusion: Our overall results suggest that non-physician clinicians display similar or equal levels of knowledge for the provision of primary care, pneumonia treatment and screening of type II diabetes than Medical Officers and could, hence, deliver equal quality primary health services as physicians. Although task-shifting might not undermine the quality of primary care delivered in Nigeria, the low levels of overall knowledge across all cadres call for greater efforts to improve health worker knowledge.

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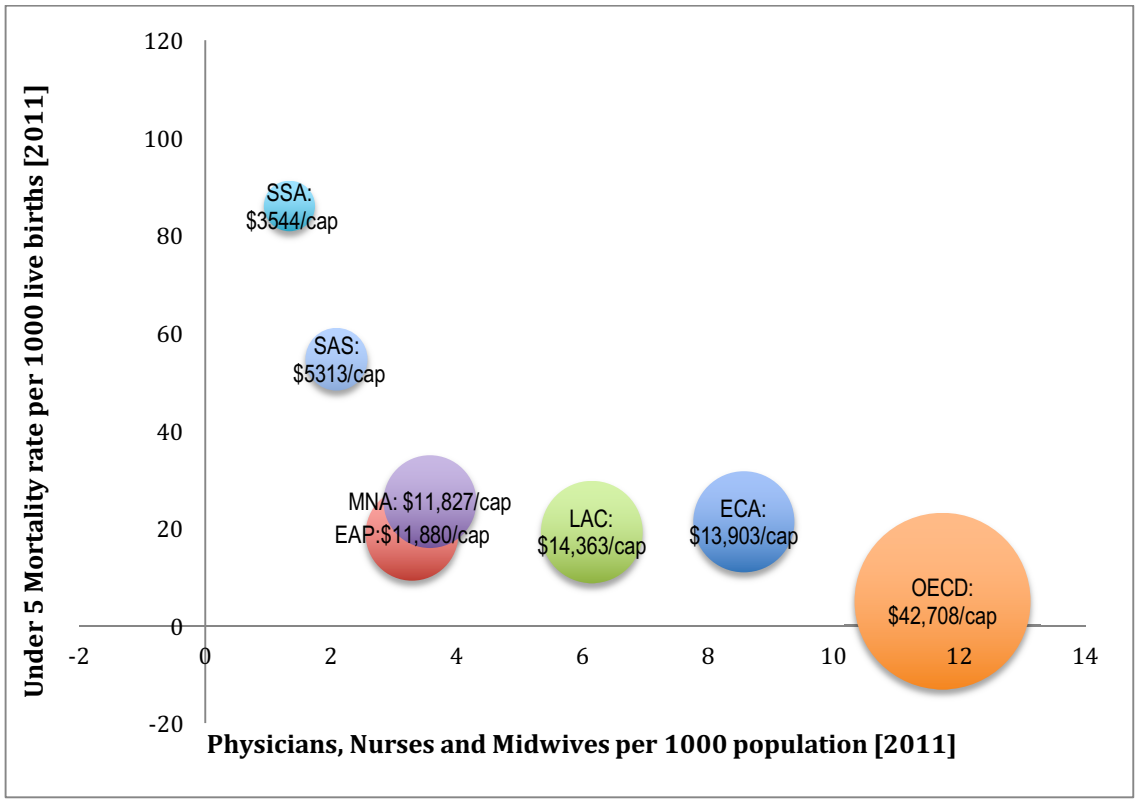
Chapter 1: Introduction

Health worker shortages have been widely documented [1–3]. The latest available estimates, suggest that over a third of countries world wide have less than the 2.5 health workers (doctors, nurses and midwives) per 1000 population [4]; the number recommended by the World Health Organization to provide adequate coverage of health services [3]. The shortages affect countries with the highest rates of poverty and often, the highest burden of disease; 41 of these countries are in sub-Saharan Africa and 31 are low-income countries [1,4] (see Figure 1).

Figure 1: Under 5 mortality rates compared to the availability of health workers across regions



Source: World Development Indicators (http://databank.worldbank.org/data). ***Note:*** Size represents GDP per Capita, PPP (current international $) [2014]. Sub-Saharan Africa-Developing Only (SSA), South Asia (SAS), Middle East & North Africa-Developing Only (MNA), East Asia & Pacific-Developing Only (EAP), Latin America & Caribbean-Developing Only (LAC), East & Central Asia-Developing Only (ECA), Organization for Economic Co-operation and Development: High Income countries (OECD).

Worldwide attention to these shortages has increased since the launch of the first major report on the human resource crisis in the health sector in 2004 [1]. In 2006, the World Health Report was dedicated to the health workforce and called for greater investment and innovations to improve health worker maldistribution across and within countries, devise strategies to increase health worker performance and make efforts to create a larger workforce [3]. Not long after, in 2007, the World Health Organization endorsed task-shifting as a strategy to overcome health worker shortages defining it as "*…the rational redistribution of tasks among health workforce teams…[where] tasks are moved, where appropriate, from highly qualified health workers to health workers with shorter training and fewer qualifications in order to make more efficient use of available human resources for health*" [5].

Long before worldwide calls for action, countries with health workforce shortages had begun to implement task-shifting strategies [6] with the aim of extending medical services to underserved populations [7]. Over two dozen countries across sub-Saharan Africa and Asia have trained health care providers, who are not physicians, for the delivery of medical services [6]. Although there is variation in the training time, entry requirements and cadre names, these non-physician clinicians have been generally charged with the delivery of primary care, and in many cases, minor surgeries, obstetric care and other specialized health services [6]. The lower training times and costs has led to an increased interest in the potential role non-physician clinicians can play in reducing the impact of health worker shortages and in contributing towards reaching universal health coverage[8].

Although studies are often of low quality, and, overall evidence remains inconclusive (see Chapter 2 of this dissertation), current research seems to point towards possibly promising results of the ability of non-physician clinicians to provide care that was traditionally assigned

to physicians. Evidence on task shifting exists for a variety of specific tasks such as the delivery of HIV care [9–15], maternal and reproductive health [16–22], identification and management of non-communicable diseases [23–25], voluntary male circumcision [26], mental health [27,28], general health care services [29] as well as studies related to the substitution of physicians by nurses on a variety of tasks [30–35], has been documented. Very little evidence exists, however, on task-shifting of general primary care, treatment of pneumonia and the identification of diabetes patients to non-physician clinicians at primary and secondary level facilities.

In line with existing recommendations and, as an additional effort to reduce health worker shortages and maldistribution, Nigeria, approved in 2014 a task shifting policy that has charged non-physician clinicians with further responsibilities for health service delivery [36]. Although Nigeria has implemented a task-shifting strategy since the 1970's that has given non-physician clinicians much responsibility for the delivery of primary care [37], the 2014 policy further highlights the country's reliance on these health worker cadres and on their interest in exploiting their potential role for achieving universal health coverage.

It is within this context that we aimed to assess non-physician clinician knowledge of health service standards, as compared to physicians, in Nigeria. The overall aim of this dissertation is to use Nigeria's experience with task-shifting to contribute to the growing evidence on the performance of non-physician clinicians when charged with delivering services that have been traditionally assigned to physicians. This dissertation has three specific and related aims. First, to take a broad approach to performance in primary health care and assess non-physician clinician knowledge of consultation process guidelines, diagnostic accuracy and treatment guidelines across five illnesses of public health importance in Nigeria, as compared to Medical Officers. Second, aim was to focus specifically on the case of childhood pneumonia (an illness of

current primary concern) and assess non-physician clinician knowledge of treatment guidelines as compared to Medical Officers. Third aim was to assess health worker knowledge necessary for screening patients with type II diabetes, an illness of growing prevalence in Nigeria.

DATA SOURCE

The data analyzed for this dissertation were collected as part of the World Bank's Service Delivery Indicator (SDI) program. One of the primary objectives of the SDI initiative is to make publicly available, data on service delivery from the health and education sectors that is representative at a national or subnational level. As part of this objective the initiative encourages the use of the data for research purposes and accountability. Nigeria is one of 10-15 countries where the SDI survey has been used to collect data on service delivery.

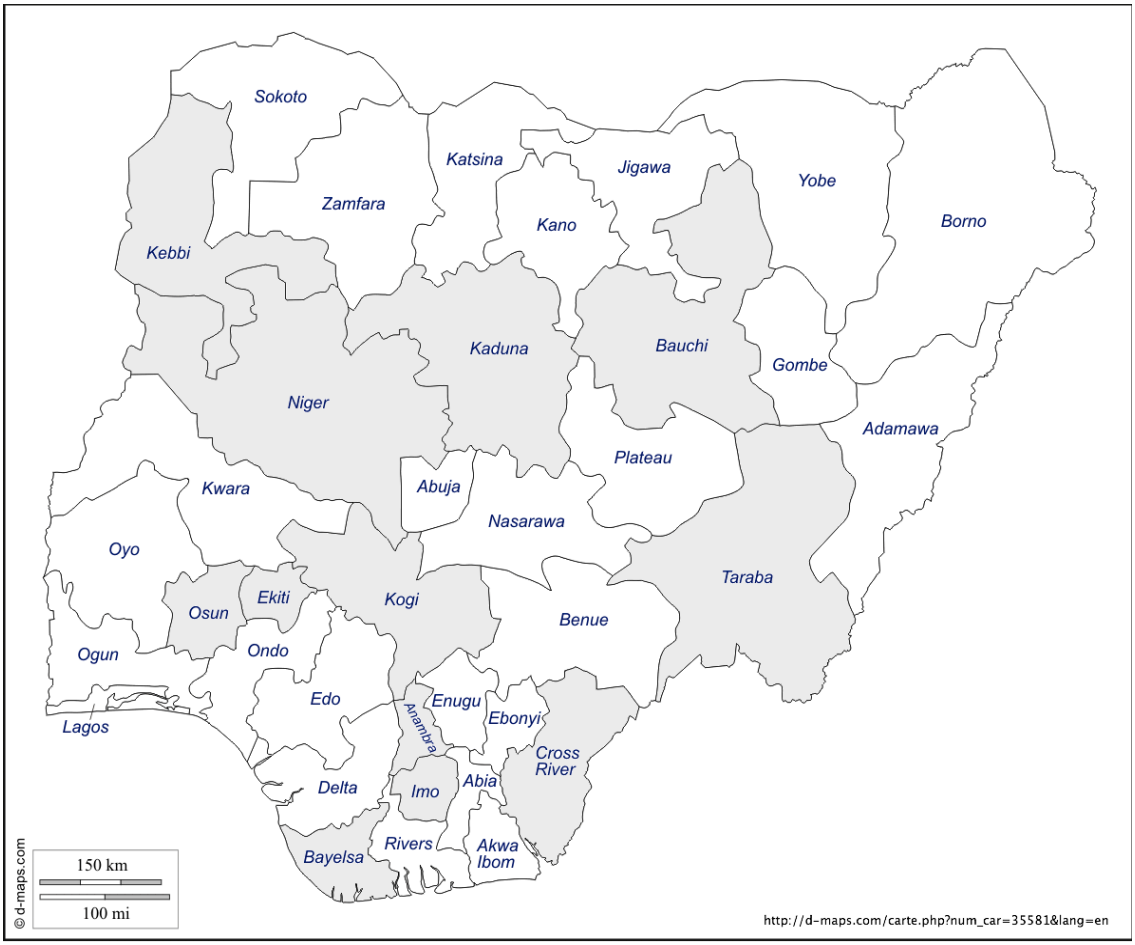
Working as part of the SDI initiative, in 2013, I was in charge of managing, as a country coordinator and health specialist, the health arm of the survey. In 2012 I worked intensively in the development of the initial health questionnaire that was used in Kenya. In 2013, I oversaw the adaptation and pretesting of the questionnaire used in Nigeria and managed the relationship with the firm that conducted training and undertook data collection and entry. With the purpose of ensuring high quality in data collection, my role included the review of the data entry program, definition and review of the sampling frame, review of the sampling strategy, initial training of the trainers, supervision of training sessions, supervision of pretest and initial data collection as well as intensive supervision in the mid and final weeks of data collection for the first six states where data was collected as well as the supervision of data entry. The work also included the management and coordination of a World Bank hired

supervision team that was responsible for data collection supervision throughout the data collection period.

Study population

Stratified random sampling was used to select facilities from the official Federal Government list of public health facilities in Nigeria. Only facilities providing primary and secondary level care were selected. The World Bank, in agreement with the Nigerian Federal Government purposively selected the 12 States from which the sample would be drawn (see Figure 2). The 12 selected States are from each of the different regions of the country but the sample is not representative of the entire Nigerian public health system, it represents only public facilities in the 12 selected states. For each state the sample was stratified by urban and rural status and by level of care provided (grouped into primary and secondary facilities). Approximately 190 facilities were sampled in each State to allow for the detection of 20 percentage point differences in proportions, with a 95% confidence and 80% power when comparing rural to urban facilities or primary to secondary level facilities within each state (refer to the Annex for more details on the sampling strategy).

Figure 2: Map of Nigerian States included in the survey



Note: Study states are shaded in grey

In each facility, health workers who reported providing outpatient consultations more than once per week were selected for the health worker knowledge interview (module 3). In facilities with less than 10 health workers that reported providing outpatient consultations more than once per week, all health workers present in the facility on the day of the survey or the day of the surprise second visit, were interviewed. In facilities with more than 10 health workers meeting the criteria, a list of the names of all consulting health workers was created and from this list, enumerators randomly selected 10 health workers. The random selection of these health workers was done using a random number table. The enumerators were trained extensively in the random selection process and were asked to record each step, which was

verified by their supervisor.

A total of 2480 randomly selected public primary health care facilities and secondary level hospitals in 12 Nigerian states were included in the survey (Table 1). Over 5100 health workers who provide outpatient consultations at these public primary health care facilities and hospitals were assessed for their ability to correctly diagnose and treat 7 common illnesses.

Table 1: Basic characteristics of survey sample

	By Facility		By Health Worker	
	(N)	(%)	(N)	(%)
Facility Type	2,480		5,192	
Posts & Dispensaries	567	22.86	771	14.85
Health Clinics	468	18.87	855	16.47
Health centers	1,135	45.77	2,610	50.27
Hospitals	310	12.5	956	18.41
State	2,480		5,192	
Anambra*	199	8.02	407	7.84
Bauchi*	212	8.55	358	6.9
Bayelsa	181	7.3	381	7.34
Cross River*	205	8.27	457	8.8
Ekiti*	208	8.39	532	10.25
Imo	230	9.27	558	10.75
Kaduna	215	8.67	404	7.78
Kebbi*	209	8.43	536	10.32
Kogi	206	8.31	343	6.61
Niger*	208	8.39	443	8.53
Osun	214	8.63	453	8.72
Taraba	193	7.78	320	6.16
Urban/rural	2,479		5,190	
Urban/Semi-Urban	998	40.24	2,433	46.86
Rural	1,481	59.72	2,757	53.1
Survey Round	2,480		5,192	
1 (July-Aug 2013)	1,241	50.04	2,733	52.64
2 (Nov-Jan 2014)	1,239	49.96	2,459	47.36

Note: Percentages are unweighted. *Data collected from these states between July and August 2013

The data collection instrument

The survey questionnaire is structured around 5 modules that provide information on the quality of health service delivery in a facility. The first module collects information on infrastructure including availability of water, electricity and sanitation, availability of equipment and availability of medicines. The second module collects information on human resources in the facility, including cadre, level of education, years of experience and personal characteristics such as gender and age. It also collects information of health worker absenteeism from a second unannounced visit to the facility. The third module collects information on the knowledge of health workers who provide outpatient consultations through the use of clinical vignettes[1]. The fourth module collects information on facility finances, including the receipt of funds and goods from a number of different sources, the expenditures of the facility, the collection of user fees and aspects of planning and financial management. The fifth module collects information from patients who were exiting the facility at the time of the survey, on the reasons for care seeking, out-of-pocket expenditures, satisfaction and trust of health care workers and finally socio-economic characteristics. Adults having received care themselves as well as adults accompanying a child were interviewed in each facility. This dissertation work uses only data collected in Module 3 of the survey.

Data collection using clinical vignettes

The clinical vignettes used in this study were originally developed by a team of World Bank experts for the pilot implementation of the Service Delivery Indicator survey in Senegal and Tanzania [38] and were again reviewed and validated, to fit the Nigerian context and clinical guidelines in 2013. Although clinical vignettes are correlated with health worker performance,

[1] Vignettes are hypothetical patient cases of a (i) child with diarrhea with severe dehydration, (ii) a child with pneumonia, (iii) a child with malaria with anemia, (iv) an adult with tuberculosis, (v) an adult with diabetes mellitus, (vi) a case of neonatal asphyxia and (vii) a case of post-partum hemorrhage.

they exclusively measure a health worker's knowledge of how to undertake a consultation [39,40]. The five clinical vignettes analyzed in this study are structured and delivered in a similar manner. Before the interview began, enumerators explained the interview process, recorded basic health worker information and performed a demonstration of a clinical vignette where one acted as the interviewer and the other as the health worker. The health worker being interviewed was encouraged to ask any questions of clarification and provide their consent to proceed with the interview. For each hypothetical case, the enumerator acting as the patient presented him/herself, mentioning basic symptoms and the reason for seeking care. The pneumonia case for example, begins as follows: "Good morning (afternoon) doctor. I am the mother of this 5 year-old girl. Her name is Sia. She has a cough." Following the introduction of the hypothetical patient, the health worker asked any questions that are relevant for him/her to reach a diagnosis and treatment. The questionnaire is designed for the "patient" enumerator to provide predefined answers to the health worker's questions. For example if the health worker in the pneumonia case asks about the duration of the cough, the enumerator responds "5 days". The health worker can verbally perform a physical examination by asking such questions as the temperature, for which the standardized response would be "38.5°C" or they can mention that they would observe breathing for lower chest in-drawing for which the response would be "no chest in-drawing". All health workers were asked to give a diagnosis and recommend a treatment for each hypothetical case. The "observer" enumerator recorded all questions asked by the health worker for each hypothetical case. All health workers were presented with the same cases in the same order. The interview was only interrupted when the health worker expressed the need to take a moment to attend to his or her patients. The majority of interviews were completed without interruptions.

Data collection process

Data were collected from facilities in six states between July and August of 2013 and collected from the other six states from November 2013 to January 2014. The rainy seasons of March-July and September-October were generally avoided for data collection. Each health facility was visited twice by a pair of trained enumerators. The first visit was announced and the second visit, at least two days later, was unannounced. In each facility, data were collected by two enumerators, each assigned specific roles. One enumerator, recruited with a health service provision background, was responsible for collecting information related to the facility's infrastructure, equipment and medicines and for administering the vignettes. The second enumerator, recruited with an accounting or recordkeeping background was responsible for collecting information on facility staff and facility financing. To the extent possible, all information, with the exception of health worker absenteeism (recorded from the unannounced visit[2]) was collected on the first day.

Ten pairs of enumerators were assigned to each state for data collection. Each state team was managed and closely supervised by a state team leader who was responsible for organizing data collection logistics, accompanying and supervising one enumerator pair per day and verifying the accuracy and completeness of questionnaires. Special efforts were made to recruit enumerators and state team leaders from the state in order to facilitate access to health facilities and ensure easy communication in the local language with health workers and exiting patients.

Supervisors and enumerators received two weeks of training on general data collection and

[2] A second unannounced visit was conducted in every facility solely for the purpose of assessing health worker absenteeism. The list of health workers assigned to the facility was prepared during the first visit, 10 health workers from the list were selected randomly and on the unannounced visit, during normal working hours, as in a snapshot in time, their presence was recorded.

recording methods and specifically on each survey module. The training included practice sessions where enumerators interviewed each other and received feedback from trainers and team leaders. The training sessions were administered by training experts of the survey firm.

Four World Bank staff were present during the training, the initial week and the last weeks of data collection for quality supervision. Two World Bank staff (a field coordinator and a medical expert) accompanied the entire data collection, supervising team leaders, enumerators, checking questionnaires and overseeing data-entry. Both the survey firm and World Bank staff performed call-backs and verification visits to randomly selected facilities to verify the accuracy of data collection. Each questionnaire was entered twice by trained data entry clerks; once in the field and a second time in Abuja.

NIGERIAN CONTEXT

Basic Indicators

Nigeria is a country of 168.8 million people (2012 estimate, [41], located in western Africa. With a large extractive industry of oil and considerable reserves of natural gas, it is a country of great wealth and poverty. While Nigeria is wealthier than most sub-Sahara African countries, it is also more unequal: as a lower middle income country, Nigeria's GDP of $459.6 billion (current US$) stands above many other African countries and so does its percentage of population living on less than $2 (PPP) per day; 84.5% in 2010 [41]. Nigeria is a federal country divided into 36 states and a federal capital territory. Managing 50% of government revenue, the states are responsible for the delivery of public services. With approximately 200 ethnic groups and over 500 indigenous languages, there are large social and economic differences across the regions in

the country. The north of the country is mainly ethnically Hausa-Fulani, the southeast mainly ethnically Igbo and the southwest mainly Yoruba (World Bank Nigeria Country Profile 2014).

Health Outcomes in Nigeria

Although trends show some improvements, the Nigerian health system faces many challenges. Nigeria is a country that has historically suffered from a high burden of communicable diseases but over the past decades, the fast growth of non-communicable illnesses has led to a greater strain on the already burdened system. With a total fertility rate of 6.02 (2012) and a slowly increasing life expectancy at birth (52 years), the Nigerian population has continued to increase, with 44.2% of its population under the age of 14 [42]. Mortality rates have decreased but continue to be much higher than the regional averages. The recent Demographic and Health Survey (2013) found under 5 mortality rates of 128 per 1,000 live births, a reduction from 201 deaths per 1,000 live births reported in 2003. Under 5 mortality rates are an indication of the burden of communicable diseases, approximately 15% of these deaths are caused by pneumonia, amounting to 120,000 children each year [43]. On the other hand, Nigeria's burden of Diabetes is estimated to be currently increasing by 125,000 cases each year [44]. With these estimates, Nigeria will have over 5.3 million adults living with diabetes by the year 2030 [44].

Health Financing in Nigeria

As of 2012, Nigeria spent US$94.33 (current) per capita on health, 6.07% of its GDP. Of the total health expenditure, 31% was public and 66% came from out-of-pocket expenditures [41]. The 2003-2005 National Health Accounts found that while in 2005, 68% of health expenditures were out-of-pocket, the Federal Ministry of Health spent 7% of total health expenditures, other federal agencies another 7%, State Ministries of Health 5% and Local Government Area Health Departments spent 6%. Of the total health expenditures in 2005, 75% was spent on curative

care, 10% on public health preventive care, 3% on rehabilitation care and 12% on other activities [45]. In 2005, private health facilities received 33% of the total health expenditure while 55% was received by public health facilities at the federal, state and local government levels. As with health outcomes, there is a large difference in per capita state total health expenditures ranging from 2,945.65 Naira (~US$17) to 11,513.14 Naira (~US$69), with an average of 6,447.16 Naira (~US$38) [45].

Health services delivered by the public sector in Nigeria are not free. As of December 2009, only 9 of the 36 states offered free Maternal and Child Health (MCH) services and 14 partially offered free MCH services [46]. A study of out-of-pocket expenditures for under-five illnesses in a semi-urban community in Nigeria, found that the median expenditure for illness episode was approximately US$1.20 [47]. A World Bank study of service delivery in four Nigerian states found large differences in the percentage of households charged for public primary care services. For child health care for example, Cross River state charged 16 percent of households for services while Kaduna state charged for 79 percent of households for services [48].

Health Service Delivery in Nigeria

The management and financing of public health service provision in Nigeria is organized in accordance with the three levels of government of the federation: Federal, State and Local. Local government areas (LGAs) are mandated by the constitution to finance and manage primary health care. Local Government Areas are composed of a 7-15 of Wards, each one expected to provide health services with at least one primary health facility. The management and financing of secondary care, including general hospitals, is the responsibility of state governments. Tertiary care, including specialist, teaching hospitals and federal medical centers fall under the responsibility of the federal government [49].

Health services in Nigeria are delivered in both the public and the private sectors. Among facilities registered with the Federal Ministry of Health, in 2005, 38% were privately owned; of these, approximately 75% provide primary care and 25% secondary care. Primary level facilities include health centers and clinics, dispensaries and health posts that generally provide preventive, curative, promotive and pre-referral care. Primary level facilities are usually staffed with nurses, community health officers (CHOs), senior community health extension workers (CHEWs), junior CHEWs and environmental health officers. Secondary level facilities are found in each LGA or zone and they generally serve as referral centers and include general hospitals that usually provide general medical and laboratory services as well as specialized health services such as surgery, pediatrics, obstetrics and gynecology [50].

With the aim of ensuring the equitable delivery of a basic set of primary care interventions to the entire population, the Nigerian National Primary Healthcare Development Agency developed the Ward Minimum Health Care Package. The package defines the minimum set of interventions to be offered at the primary care level. Part of the rationale for defining the package was to mobilize political commitment for health service delivery from all levels of Government. The plan for implementation of the package draws specifically on the Ward Development Committees to mobilize resources and provide the supervision necessary for the implementation. The interventions are to be delivered at health posts, health clinics and health centers that are staffed primarily by Community Health Extension Workers with the support of nurses and midwives at the health center level [51].

Health Service Utilization in Nigeria

Even though there is a large variation across states within Nigeria, indicators of service delivery and utilization generally fall below regional averages. Using data from 6 states in Nigeria, the World Bank's SDI survey points to much lower caseloads per health worker per day than other countries where the survey has been implemented [52]. According to the survey, the caseload in primary health facilities for Nigeria is estimated to be 5.2 outpatient consultations per health worker per day while in Kenya this number is estimated to be 8.7 and in in Uganda, 10.0 [52]. Low caseloads translate to low coverage of basic interventions. The percent of children under 5 years of age that had received 3 doses of the DPT vaccine by 2013, was 38.2% [42], much below the regional average of 71% [41]. The most recent DHS data for 2013 show the percentage of total births attended by skilled health staff in Nigeria was 38.1%, ranging from 5.4% in Sokoto to 96.5% in Imo [42]; lower than the regional average in 2010 of 49.7% [41]. The percentage of births attended in a health facility according to the latest DHS data is 35.8%, ranging from 4.7% to 90.9% between States [42].

Not only is there a variation in utilization of health services across states in Nigeria but variation in utilization across income groups and between rural and urban areas. Using the 2003 DHS data, a World Bank report calculated the difference in full immunization rates to be 13 times higher among the richest 20% than the poorest 20% of the population[48]. Using the Nigerian Living Standard Survey (NLSS) from 2004, this same report calculates that among those ill or injured in the two weeks prior to the survey, only 60 percent visited a health care provider. Among the poorest 20 percent, only 30 percent of those ill or injured in the two weeks prior to the survey had visited a health care provider compared to 72 percent among the richest 20 percent. The report also found, using the NLSS data, that the poor are more likely to use

primary health care facilities for outpatient care and less likely to use a private provider than the rich [48].

Different barriers to utilization of public primary health services in Nigeria have been reported. Using data from 4 states, a World Bank study found that 18 percent of rural households, 38 percent of urban households and 18 percent of semi-urban households do not patronize their nearest primary health care facility. The reasons for this were primarily the perceived lack of equipment and lack of doctors for rural households, and the cost of services and lack of equipment in urban and semi-urban areas [48]. Similarly, in a study of barriers to the use of antenatal and obstetric care in Kano state in Nigeria, researchers found that 46 percent of respondents considered financial constraints as the primary reason for not using antenatal care[53].

Quality of care in Nigeria

Studies of the quality of care in Nigeria have found differences in availability of medicines and equipment across different facilities. A study of primary health facilities in the city of Calabar in Cross Rivers state found that 71.4 percent of facilities included in the study had fairly adequate or adequate equipment to deliver childhood health services and 60 percent had an adequate supply of medicines [54]. Another study used facility level data from 4 states to assess the availability of equipment and medicines for primary care services, found differences in availability of equipment across facility levels (only 67 percent of health posts had a functioning thermometer available compared to 88 percent of health clinics) with big differences between rural and urban facilities (48 percent of rural facilities having ORS sachets available as compared to 72 percent of urban facilities) [48].

Human resources for health in Nigeria

The quality of health service delivery and human resources for health are of primary concern to the government of Nigeria. In 2010 the Federal Government of Nigeria drafted the first overarching National Strategic Health Development Plan (2010-2015). The plan is meant to serve as the reference document for policies and actions in the health sector, by all levels of government. The plan has eight strategic development areas, which include service delivery and human resources for health. Under the strategic area of health service delivery lie three objectives: (i) the universal availability of an essential package of health care services (ii) the improved quality of primary health care services and (iii) the increased use of primary health care services. Under the strategy for human resources for health lie two objectives: (i) the implementation of human resources for health policies that ensure adequate staffing in all facilities and (ii) the state level development of human resources for health plans to increase the number of health workers per population. Among many activities outlined to achieve these objectives, the plan includes the training of providers and supervisors for improved quality in service delivery and the accreditation and monitoring of compliance of health worker training institutions [55].

The Nigerian health workforce is very large, comparable only to Egypt and South Africa in the region. However, the number of health workers is insufficient for its large population and they are inequitably distributed, as can be seen in Table 2. While Nigeria has over 56,000 doctors and nearly 225,000 nurses and midwives, with a population of approximately 170 million, this amounts to too few health workers per capita [56]. According to a 2006 study of public sector health workers, the number of doctors varied three fold across regions in Nigeria, with 7 doctors per 100,000 population in the North East Region compared to 21 in the South West Region, and varied fivefold for nurses and midwives with 30 per 100,000 population in the

South East Region and 155 in the North Central Region. The variation in distribution of community health workers and officers is also very large with 18 per 100,000 population in the South East Region and 101 in the North Central Region [57].

Table 2: Registered Health Workers in Nigeria in 2008

	Absolute number	per 1,000 population
Physicians	56,526	0.403
Nursing and midwifery personnel	224,943	1.605
Community and traditional health workers	19,268	0.137
Pharmaceutical personnel	18,682	0.133
Laboratory health workers	23,523	0.168
Environment and public health workers	4,280	0.031
Dentistry personnel	3,781	0.027
Other health workers	1,473	0.011

Source: *WHO Global Health Observatory, 2014.*

Efforts to improve the number and distribution of health workers in Nigeria have relied on a rather limited number of educational institutions. In 2002/03, with 18 fully and 5 partially accredited medical schools, Nigeria had the capacity to produce approximately 2,000 doctors, 5,500 nurses and 800 pharmacists per year [57]. As of 2007, 33 states had approved nursing training schools with some states with as many as 5. The majority of states have midwifery training institutions [49].

Non-physician clinicians in Nigeria

Non-physician clinicians have been recognized in the National Strategic Health Development Plan (2010-2015) as primary health care providers. The improvement in training and number of non-physician clinicians is one of the important strategies proposed in Nigeria for increasing access to health services in rural and remote areas [55]. Nigeria has over 19,000 community health workers and nearly 225,000 nurses and midwives distributed throughout the country [56].

There are five cadres of formally contracted non-physician clinicians in Nigeria; Community Health Officers (CHOs), Community Health Extension Workers (CHEWs), Junior Community Health Extension Workers (JCHEWs), Nurse Officers and Nurse Midwives [58]. CHOs, JCHEWs and CHEWs hold an Ordinary National Diploma or a Higher National Diploma from schools or colleges of Health Technology. CHOs receive four years of postsecondary training in the delivery of primary health care services, CHEWs receive 2 years of training and JCHEWs, one year of training [48]. Nurse Officers receive 3 years of training while Nurse Midwives can be a nurse with additional training as a midwife [59].

CHOs are trained to deliver primary health care services and are expected to take on management responsibilities in Primary Health Care Centers. CHEWs and JCHEWs are health workers who are specially trained to provide primary health care treatment and preventive services serving in health posts, primary health care centers and clinics. As paid, full time, health workers, CHEWs and JCHEWs are expected to spend a 50% of their time in their communities conducting health promotion activities and the rest of their time in clinics providing integrated primary care services [60]. At the health facility, CHEWs and JCHEWs perform consultations, write prescriptions and perform basic treatments as guided by 'National Standing Orders'. The training of CHOs, CHEWs and JCHEWs is regulated by the Community Health Practitioners' Registration Board of Nigeria that was constituted in 2000 [61]. Nurse Officers are trained to triage and deliver supportive care while Nurse Midwives are trained to deliver basic obstetrics and gynecology services. Neither is trained explicitly to provide outpatient consultations nor to prescribe medications [59].

Nigeria's National Standing Orders for CHOs, CHEWs and JCHEWs were developed in 1974 and were last updated in 2010. The National Standing Orders are Clinical Practice Guidelines

developed with a number of purposes in mind. Firstly, they are to provide reliable enough guidance to decrease the patient burden on hospitals and doctors by ensuring the availability of quality health services in primary care facilities. The rationale was for the guidelines to act as a simple and accessible guide for lower cadre health workers in the identification and treatment of patients with common but basic illnesses (including common childhood conditions such as diarrhea, pneumonia, malaria and adult conditions such as tuberculosis and type II diabetes). The guidelines are meant to ensure quality care and with their systematic approach to consultations and treatment, reduce the time burden on health workers and the costs of unnecessary tests, supplies and medicines. As such, these guidelines are also the basis for the training of CHOs, CHEWs and JCHEWs in Nigeria [37].

Salaries for government health workers vary across states and depend not only on cadre but also on years of experience. A 2007 study, in four Nigerian states, calculated that on average Medical Officers working in public primary health care facilities earned a monthly salary of approximately US$193 (current exchange rate), CHOs earned US$148, Nurses and Nurse Midwives earned US$165, CHEWs earned US$104 and JCHEWs earned US$78. Some states provide financial incentives to these cadres of health workers employed in rural areas and some provide housing, transportation and food benefits [48].

Health worker knowledge in Nigeria

A small number of studies have assessed health worker knowledge in Nigeria. One study of the quality of childhood health services in primary health facilities in the city of Calabar, Cross Rivers, Nigeria found that only 36.9 percent of the health workers knew the correct definition of diarrhea and that 74.2 and 38.1 percent followed more than half of the actions indicated in the clinical guidelines for the management of diarrhea and acute respiratory infections (ARI)

respectively [54]. The authors found no significant difference between health workers that had attended training on ARI or diarrhea, and those that had not, but did find significant differences across cadres. Another study of the knowledge of non-physician clinicians for the management of ARI in Anambra state, found no significant difference between JCHEW, CHEW and CHO knowledge. The authors also found a relatively low level of knowledge of the symptoms of ARI with 37.6, 47.6 and 57.0 percent of JCHEWs, CHEWs and CHOs respectively identifying fever as a symptom and 43.7, 59.2 and 84.5 percent respectively identifying chest in-drawing as a sign of an ARI [62]. Unfortunately, the small sample sizes of these studies were not large enough to detect the small differences reported.

ORGANIZATION OF THE DOCUMENT

The remainder of this dissertation is organized as follows:

- Chapter 2 presents a review of available literature on task-shifting from higher level-cadres to non-physician clinicians, world wide.

- Chapter 3 (Paper 1) examines differences in knowledge regarding primary care consultation processes, diagnostic accuracy and treatment guidelines between Medical Officers and non-physician clinicians working in public primary care facilities in Nigeria.

- Chapter 4 (Paper 2) assesses the difference in knowledge of pneumonia treatment guidelines between Medical Officers and non-physician clinicians who are posted to public primary and secondary facilities in Nigeria.

- Chapter 5 (Paper 3) assesses the difference in knowledge of consultation guidelines and identification of a hypothetical case of type II Diabetes between Medical Officers and non-physician clinicians providing public primary care in Nigeria.

- Chapter 6 summarizes the findings, provides conclusions and recommendations.

Chapter 2: Review of studies comparing performance of non-physician clinicians to higher-level cadres.

ABSTRACT

Background: Health worker shortages and maldistribution within low and middle-income countries have led to calls for innovative solutions. Over the past decade, task-shifting strategies have been implemented across a variety of countries and contexts where non-physician clinicians have been tasked with roles traditionally assigned to physicians.

Methods: To provide an overview and assessment of recent evidence on performance of non-physician clinicians compared to higher-level cadres, we undertook a scoping review of studies published between 2005 and 2015, specifically focusing on the study location, non-physician clinician cadre types, tasks, study methodologies and findings regarding performance.

Results: We found a total of 46 studies from across the world, on task shifting strategies that include HIV care and management, minor surgeries and IMCI. Study findings suggest inconclusive evidence of the performance of non-physician clinicians on a variety of tasks as compared to higher-level cadres. Small sample sizes and failure to conduct clustered analyses invalidate the findings of the majority of available studies.

Conclusion: Inconclusive available evidence, sparse research on task-shifting for primary care and inadequate sample sizes across studies suggests the need for further research.

INTRODUCTION

Health worker shortages in low and middle-income countries have been widely documented[63,64] and calls for action are ubiquitous[2,16,65–68]. In 2004, the Joint Learning Initiative published the first international report arguing for the need to find innovative solutions to the human resources crisis in the health sector[1]. Published two years later, the World Health Report of 2006 was the first major report to call for task-shifting as one of several potential strategies to combat issues of human resources for health in low- and middle-income countries[3]. To follow suit, one year later, the World Health Organization proposed task-shifting as one of these solutions, calling for the adoption and expansion of task-shifting as a method to rapidly expand the health workforce and increase access to health services[5]. In their report, the World Health Organization defined the task-shifting strategy as "*…the rational redistribution of tasks among health workforce teams…[where] tasks are moved, where appropriate, from highly qualified health workers to health workers with shorter training and fewer qualifications in order to make more efficient use of available human resources for health*"[5]. As more evidence on task-shifting has become available, the recent health workforce strategy has again called for task-shifting and flexible health worker role definitions, but this time, warning against over-relying on this strategy[67].

Task-shifting strategies are already commonly employed. Task-shifting to non-physician clinicians has been documented in a large number of countries in sub-Saharan Africa where new and existing cadres have been charged with the delivery of primary care, and in many cases, minor surgeries, obstetric care and other specialized health services[6]. The rationale for implementing non-physician clinician programs has often been to extend medical services to underserved populations[7] and staff rural health facilities with health workers who have a

higher likelihood of remaining in their posts[69]. Trained faster and at a lower cost than physicians, non-physician clinicians are increasingly seen as central to universal health coverage strategies [8].

Over the past years, systematic reviews have gathered existing evidence on task shifting of specific tasks such as the delivery of HIV care[9–15], maternal and reproductive health[16–22], identification and management of non-communicable diseases[23–25], voluntary male circumcision[26], mental health[27,28], general quality of care[29] as well as studies related to the substitution of physicians by nurses on a variety of tasks[30–35]. With evidence coming predominantly from low- and middle-income country settings, these reviews have generally found inconclusive but possibly positive results of task-shifting although most point to the overall low quality of available evidence. The one review on the quality of care provided by non-physician clinicians included studies published up until 2012 as well as non-peer reviewed studies[29]. With this review we aimed to include the latest available peer-reviewed evidence but restrict our findings to studies published after the first report on the human resources for health crisis in 2005[1].

This scoping review sought to describe recent evidence on task shifting performance of non-physician clinicians compared to higher-level cadres. Specifically, we sought to document the variation in study context, methods, sample size, types of non-physician clinicians assessed, study findings and to identify important areas of further research. Our review focused on peer-reviewed literature published between 2005 and 2015.

METHODS

We performed a scoping review of studies on the performance of non-physician clinicians in the delivery of health services when compared to higher cadre health workers. In line with the search strategies of similar reviews, we conducted a search on the Medline database using the terms, "task-shifting", "task-sharing", "mid-level cadre", "non-physician clinician", "physician substitution", "nurse substitution", "doctor substitution + task", "task reallocation", "task delegation". We also conducted a search for systematic reviews using the terms "task-shifting" and "non-physician clinicians" on the Cochrane library. We used systematic reviews, from both searches, to identify any further relevant studies. Only articles published in peer-reviewed journals between the years 2005 and 2015 were included in the review.

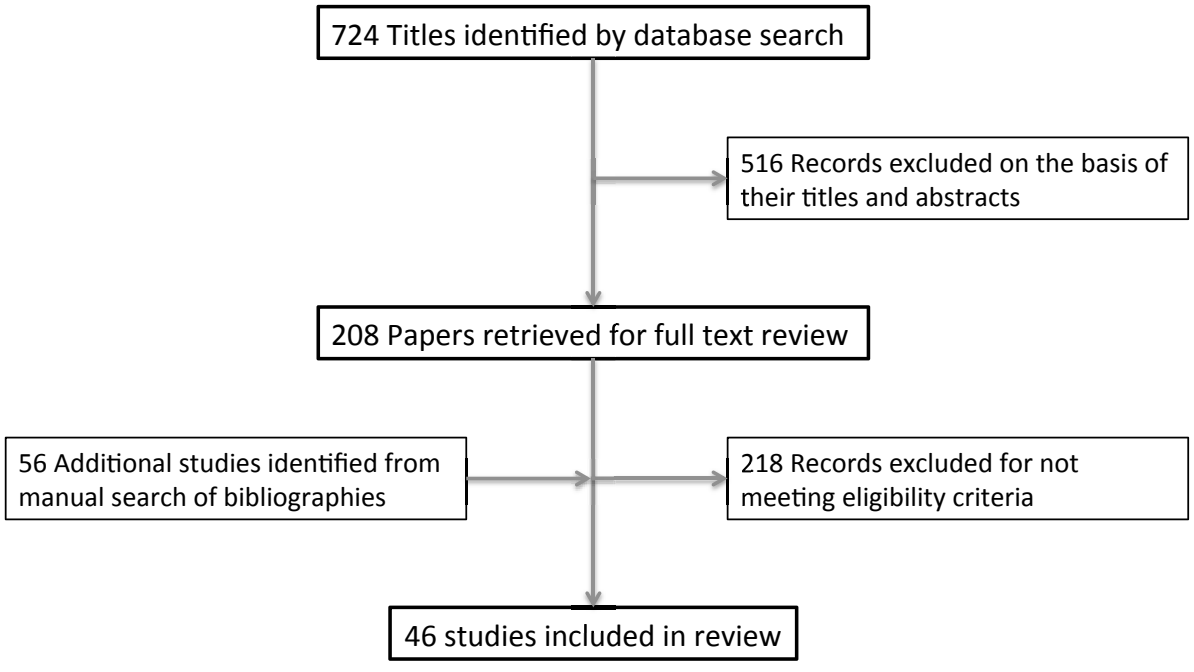
We included randomized trials and observational studies from low-, middle- and high-income countries across all regions, published in English, in a peer-reviewed journal between 2005 and 2015. For the purpose of this study, we defined non-physician clinicians as health care providers that are not a medical doctor or physician nor a lay community health worker, who provide clinical care in the community or primary care facility or hospital. We defined task-shifting as the provision by non-physician clinicians of one or several health care services/interventions traditionally assigned to medical doctors or physicians. Performance was defined in relation to patient health outcomes related to the intervention in question, health worker knowledge in relation to a gold standard or specific guideline, or patient satisfaction with the receipt of the intervention or services. Only studies comparing performance in the delivery of care between non-physician clinicians and a higher-level cadre health worker were included: we excluded any study that did not compare performance

between higher and the lower level cadres. We excluded studies that compared lower to higher-level health facilities if their cadre mix was not specified.

RESULTS

The search identified 724 database records whose titles and abstracts were reviewed for inclusion. The initial review led to the retrieval of 208 articles for a full text review (Figure 3). A manual search through the bibliographies of literature and systematic reviews identified an additional 56 articles whose full text was also reviewed. A total of 46 articles were identified to meet the inclusion criteria for this review [see Table 3 for study details].

Figure 3: Database search for studies of non-physician clinician performance compared to higher-level cadres, 2005-2015



Study Design

We identified 14 randomized trials[70–83] and 32 observational studies published between 2005 and 2015. A total of 9 observational studies had a cross-sectional design [84–92], one had a repeated cross-sectional design[93], 12 had a prospective cohort design [94–105]and 10 had a retrospective cohort design [106–115]. Studies used a variety of sample sizes for their analysis.

All but 5 of these studies[71,73,85,96,115] reported on the number of facilities where health workers worked or the intervention was based. Of the 41 studies, over a third were based on observations from patients attending or health workers assigned to only one[77,79,87,91,103,105,107,111,113,114,116] or 2 facilities[70,74,80,100,104], 18 collected data from 3 to 20 facilities[72,78,81–83,88,92–95,98,99,101,102,108–110,112], five collected data from 38 to 78 facilities[76,84,89,97,106] and only two collected data from over 100 facilities[86,90]. Less than half of the articles (20 of 45) reported the number of health workers involved in the task shifting strategy/analysis[72,79,81,82,85,87–91,96,98,99,104,105,108–110,113,114], ranging from 4 to 456 health workers. On the other hand all but three articles (that did not investigate patient outcomes or satisfaction[85,89,91]) reported on the number of patients included in the study: patient sample sizes ranged from 40 to 19,660.

Study Location

The majority of the studies (32 of 46) report on task shifting efforts in Low and Middle-income countries. Of these, 24 were undertaken in 11 countries in sub-Saharan Africa including Botswana[113], Burkina Faso[112], Ethiopia[84,106,110], Kenya[98], Malawi[97,102,105,114], Mozambique[104], Namibia[88], Rwanda[103], South Africa[74,80,94,95,100], Tanzania[101,108] and Uganda[77,92,96,107]. We found 6

studies undertaken in South Asia; one in Bangladesh[93], one in Nepal[83] and four in India[89,90]. Two studies were multi-country studies: one included Bangladesh, Brazil, Uganda and Tanzania[86] and another compared South Africa and Vietnam[82]. We found 14 studies from high income countries that included one from Ireland[70], five from the Netherlands[72,78,81], three from the United Kingdom[71,79,87] and five from the United States[85,91,109,111,115].

Tasks

The largest proportion (18 of 46) of task-shifting studies published over the last 10 years relate to HIV care and preventive services. We found 11 studies on task-shifting performance related to antiretroviral medicine prescription or management for people living with HIV/AIDS[77,80,84,88,92,94,95,100,102,106,107]. Three studies assessed shifting tasks related to the general care of HIV/AIDS patients[74,104,113] and one related to the care of children with HIV/AIDS[105]. Three other studies assessed task-shifting of voluntary male circumcision for the decreased risk of HIV infection[96,98,103]. Nine studies assessed performance in surgery related tasks including two that assessed health worker performance undertaking cesarean sections[97,112], two others related to comprehensive emergency obstetric care[101,110], two related to general or major surgery[108,114], one to post-operative surgical care[71] and one to pre-operative assessment[79]. Eight studies were related to care of patients with non-communicable illnesses; the tasks include asthma care[78], breast cancer[115] or cardiovascular risk screening[76,81,85], treatment of dyslipidemia, diabetes mellitus and hypertension[75,109] and management of urinary incontinence. Five studies assessed health worker performance related to maternal and child health, including abortion care[82,83,99], neonatal resuscitation[91] and care of healthy women at low risk of childbirth complications[70]. Only six studies assessed health worker performance in primary

care, including general primary care[72,89,90], acute care[87] and IMCI[86,93]. Finally, one study assessed health worker performance related to emergency medicine[111].

Task-shifting from whom to whom?

The large majority of the studies (39 of 46) included in this review, assess performance in the delivery of a given task by comparing physicians to non-physician clinicians. Among the studies that compare physicians to non-physician clinicians, 18 assess the performance of tasks undertaken by nurses[71–75,77–81,87,88,94,95,99,100,103,113]. Other studies compare physicians to both nurses and physician assistants[85,91,115], health officers[84,106], clinical officers[c92] or midwives[83]. Physician performance is also compared to clinical officers[96,108,112,114], AYUSH (Indian medicine providers) and rural medical assistants[89,90], health officers[110], medical technicians[104], midwives[70], pharmacists[107], physician assistants and midwives[82], physician assistants and nurses[111], resident physicians[109] and undefined non-physician clinicians[76]. The other 7 studies compare higher cadre mid-level providers such as clinical officers to nurses[98,102,105], medical officers to assistant medical officers[101] or clinical officers[97], or a variety of health workers trained for a longer period of time, to lower level non-physician clinicians[86,93].

Performance Measures

Task-shifting studies included in this review measured a variety of outcomes to compare performance across health worker cadres. The majority of studies (26 of 46) assessed health worker performance in relation to patient outcomes by direct patient observation or

[c] The Clinical Officer cadre is a common name for a cadre of non-physician clinician across sub-Saharan African countries. Most commonly, Clinical Officers receive post-secondary training for approximately 3 years to deliver primary care. Their specific tasks often vary across countries however[6].

retrospective patient chart reviews. Of these, 10 HIV related studies measured patient outcomes such as mortality, CD4 counts, viral load, loss to follow-up or pill count[74,77,80,94,95,100,102,104,106,107]. The three studies on task shifting for male circumcision measured adverse events such as infections or bleeding[96,98,103]. Studies related to deliveries or abortions measured rates of complications[70,82,101], procedure completeness[83], maternal mortality[110], neonatal condition[97,112]. Other studies related to surgical procedures measured patient mortality[108,116] or post operative complications[114] or specific illness control outcomes[71]. Two non-communicable disease-related studies measure lipid, lipoprotein, cholesterol, blood glucose levels, blood pressure or BMI[81,109] and another measures asthma control measures such as airway responsiveness[78]. Four studies measured both patient outcomes and patient satisfaction[72,73,75,99]. Four of the 46 studies included in the review, measured patient satisfaction with the services received[84,87,90,111] as the primary outcome of interest. An additional 9 studies measured health worker performance as adherence to clinical guidelines or a gold standard for patient treatment or consultation procedures[76,79,86,88,92,93,105,113,115]. Finally, three studies measured health worker knowledge by using hypothetical cases, vignettes or a written questionnaire[85,89,91].

Study findings

Studies included in this review find both positive and negative outcomes resulting from shifting tasks to non-physician clinicians. A total of 27 of the 46 studies found no significant difference in the performance of specific tasks when comparing higher-level health workers to non-physician clinicians. Of these 27 studies, 13 found no significant difference in the performance of nurses when compared to physicians. Furthermore, 8 found no significant differences on patient outcomes such as mortality, CD4 count, viral load and loss to follow-up, when nurses as

compared to physicians, treated HIV/AIDS patients[77,80,88,92,94,95,107,113]. Five studies found no significant difference in patient outcomes and/or satisfaction when physicians were compared to nurses in the delivery of abortion care[83,99], general primary care[72], preoperative assessments[79] or neonatal resucitation[91].

Nine studies found that physicians perform no differently from other non-physician clinician cadres. No significant differences were found, on patient outcomes, when clinical officers and physicians performed major[108] or pediatric surgeries[114]. No significant differences were found between physicians, AYUSH (Indian system of medicine physicians) and rural medical assistants in their knowledge of primary care consultation processes[89], nor patient satisfaction with their services[90]. The performance of physicians and midwives for the care of healthy women with low risk of complications at childbirth[70], physicians and health officers in the provision of comprehensive obstetric care[110], physicians and pharmacists for the provision of antiretroviral treatment[107], physicians and resident physicians on the treatment of patients with diabetes mellitus, hypertension and dyslipidemia[109], physicians and nurses in the management of patients with diabetes mellitus[75] and physicians compared to non-physician clinicians in India on the screening and management of cardiovascular disease[76] was also found to not be significantly different when patient outcomes, patient satisfaction and health worker knowledge/performance were measured.

Five studies found no significant difference in the performance of higher-level non-physician clinicians with lower level cadres. No significant differences were found in the performance of medical officers compared to assistant medical officers providing emergency obstetric care[101] or medical officers compared to clinical officers undertaking cesarean sections[97]. Two studies found no significant difference in patient outcomes when clinical officers undertook male

circumcisions[98] or provided antiretroviral treatment[102] when compared to nurses. Based on consultation observations, another study found no difference in the adherence to expected tasks for the management of HIV-infected children when performed by clinical officers as compared to nurses[105].

Of the 46 studies included in this review, 8 found mixed results of task-shifting to non-physician clinicians. Three of these studies found equal or lower results of nurses and physician assistants when compared to physicians in the provision of HIV care (nurses had higher loss to follow-up rates)[74], asthma care (patients treated by nurses had lower frequency of regular office visits for patient review)[78] and on the assessment of cardio metabolic risk (nurses and physician assistants screened patients for diabetes less frequently)[85]. Two studies found that non-physician clinicians performed better in some measures but equally on others when compared to physicians in the provision of HIV care (medical technicians had lower rates of loss to follow-up and assessment of patient CD4 counts than physicians)[104] and cardiovascular risk management (patients treated by nurses had greater decrease in cholesterol than those managed by physicians)[81]. One other study found that nurses and health officers performed better on some measures and worse on others when compared to physicians delivering antiretroviral treatment (patients treated by nurses had higher increases in CD4 counts after two years of follow-up but were more likely to continue receiving care at the facility than those treated by physicians)[106]. A study comparing nurse and physician care of patients with urinary incontinence in the Netherlands found no difference in patient outcomes between these cadres but higher satisfaction among patients managed by nurses[73]. Finally one study that compared health workers trained for longer periods of time to those with shorter duration of training in Bangladesh, Brazil, Uganda and Tanzania, found a variety of results of health worker performance on IMCI care delivery (performance of health workers with shorter training was

better in Brazil and Uganda, in Tanzania those with longer training performed better and in Bangladesh, health workers with different training periods performed equally as well)[86].

Six of the 46 studies included in this review found that non-physician clinicians performed better than the physicians to which they were compared. Patient outcomes and satisfaction were significantly higher among those receiving antiretroviral treatment[84,100], breast cancer screening[115], acute care prescriptions[87] and follow-up after a gastroscopy[71] when treated by nurses as compared to physicians. Patients of clinical officers experienced lower rates of adverse events after adult male voluntary circumcision than those whose procedure was performed by physicians[96].

Finally, five of the 46 studies included in this review found significantly lower performance of non-physician clinicians when compared to higher-level cadres. Patients receiving emergency care from nurses and physician assistants were found to be significantly less satisfied than those receiving care from physicians[111], complete healing from adult male circumcision was faster for patients receiving care from physicians as compared to nurses[103], patients of physician assistants and midwives had higher rates of complications related to abortion care than those receiving care from physicians[82], the neonatal condition of babies delivered through cesarean section by clinical officers was lower than for those delivered by physicians[112] and a lower percentage of family welfare visitors (lower level cadre) provided patient management in accordance to IMCI guidelines than higher level cadres[93].

DISCUSSION

With more recent evidence, in line with the conclusions of similar reviews, we find mixed results of task-shifting across study location, tasks, types of non-physician clinicians and outcome measures which suggest that available evidence on task-shifting remains inconclusive and the implementation of successful strategies is likely dependent on a variety of factors. A review of studies of quality of care in task-shifting to mid-level health workers[29], found a majority of these showed no significant difference between physicians and nurses or midwives, but concluded that due to a low overall quality of evidence, together with some variation in results and large confidence intervals of the relative risk estimates, available evidence on task-shifting cannot be deemed conclusive. A systematic review of task-shifting for the delivery of antiretroviral therapy[117], also found some variation of results across studies pointing to probable but inconclusive evidence. The same review concludes that the delivery of HIV care by nurses or community health workers probably does not decrease the quality of care and possibly decreases the rates of loss to follow-up[117]. Another review of studies of task-shifting for the delivery of HIV treatment and care in Africa found mostly positive but also some mixed results, and interestingly concluded that challenges to task-shifting strategies include adequacy and sustainability of training, pay for staff in new roles and team integration[9]. Two other reviews also emphasize the importance of context and other programmatic-level factors on the potential success of task-shifting strategies[118,119].

Findings from this review highlight the need for further research that focuses on the ability of non-physician clinicians to deliver routine and comprehensive primary care. Interestingly, we found only seven studies, published in the last decade, that assessed performance in task-shifting of non-physician clinicians, as compared to higher level cadres, in the delivery of

routine primary care[72,86,87,89,90,93]. Task-shifting of routine primary care has been documented in a large number of sub-Saharan African countries[6], and has been considered as an important policy option to counteract the effects of a widespread human resources for health crisis or at very least, to promote the revival of the primary health care approach[5,66,118,120]. A larger body of evidence would aid in policy decisions, helping to understand the strengths, weaknesses and nuances of this human resources for health strategy.

Although available evidence might suggest there are many benefits of task-shifting especially in light of universal health coverage efforts[8], it is essential to understand that that the equality in performance of tasks by non-physician clinicians as compared to physicians is not equivalent to the provision of high quality care by these lower-level cadres. A few studies included in this review, which use a gold standard or adherence to clinical guidelines as performance measures[85,86,89,115], found that physician performance, although equal to that of non-physician clinicians did not meet high quality of care standards. These studies were only a few among a growing number that have assessed physician performance. Other studies have found low overall performance[121,122] with large quality differences between physicians in rural compared to urban areas[123,124] or working in private as compared to the public sector[125], for example. Physician performance is hence, possibly not the only standard or comparison that ought to be used to assess task-shifting strategies if quality of care is a primary objective of the strategy.

Finally, our review not only points to the need for further research on task-shifting but also for a need to design these studies and their statistical analysis in a way that yields conclusive results. Over half of all studies included in this review did not report the number of health workers whose performance was being assessed. Among the studies that did report the numbers of health workers participating in the study, only seven reported including a total of

more than 50 health workers, a sample size that could probably not yield enough power to detect differences in measured outcomes, across cadres. Although studies often include large numbers of patient outcome measures, the majority of these studies fail to acknowledge the inherent clustering of their outcomes. As an example, when five nurses and five physicians each perform 100 male circumcisions, even if outcome measures for the 1000 patients have been recorded, the analysis compares only the performance of five nurses versus five physicians, even if the study has collected repeated measures of the performance of each nurse and each physician. All recorded outcome measures attributed to each health worker ought to be seen as repeated measures of an individual's performance as these measures are not independent of each other and are most likely to display relatively low variation. Low within cluster variation translates into high intracluster correlation that in turn, greatly reduces the effective sample size on which comparisons are based[126,127]. Furthermore, if health workers in a study have not been randomly selected, inference is limited if not impossible.

For task-shifting studies that do report health worker sample size, as a reader one can potentially assess the power of their sample and statistically judge the potential for inference from the given study. For studies that do not report health worker sample sizes it is impossible to evaluate or even acknowledge the strength and importance of the findings. Low sample sizes and a non-clustered analytical approach of studies included in this review, invalidate the majority of results finding no or any statistical differences between health worker cadres, further highlighting the inconclusiveness of the available evidence on task-shifting strategies.

CONCLUSION

We find mixed results across recent studies that compare non-physician clinician performance in the delivery of health care as compared to higher-level cadres. Results across locations, tasks, types of non-physician clinicians and outcome measures used are mixed. Although task shifting strategies worldwide have focused on primary care, we find very little evidence exists on the performance of non-physician clinicians when delivering primary care, as compared to higher level cadres. A majority of studies do not report on the number of health workers or account for cluster effects related to health workers delivering a given intervention, further highlighting the inconclusiveness of available evidence on task-shifting. Our review underscores the need for further research on task-shifting in primary care with methods capable of detecting differences, if any, across cadres.

Table 3: Basic Study Characteristics

Study	Location	Task Type	From	To	Performance Measure	# of Facilities	# of Health Workers	# of Patients	Findings NPC: Higher cadre
Observational Studies									
Cross Sectional studies									
Asfaw, E. et al. (2014)[84]	Ethiopia	HIV	Physicians	Nurses and health officers	Patient satisfaction	78	430	665 NA	"+"
Gohdes, D. et al. (2009)[85]	US	Non-Communicable illness	Physicians	Nurses and physician assistants	Health worker knowledge				"=/-"
Huicho, L. et al. (2008)[86]	Bangladesh (2003), Brazil (2000), Uganda (2002), and Tanzania (2000)	Primary care	Longer trained providers	Health worker with lower time of training	Performance	265		1262	"+/-/="
Jones, K., et al. (2011)[87]	UK	Primary care	Physicians	Nurses	Patient satisfaction	1	4	122	"+"
O'Malley, G. et al. (2014)[88]	Namibia	HIV	Physicians	Nurses	Performance	9	16	40	"="
Rao, K.D. et al., (2013a)[90]	India	Primary care	Physicians	AYUSH and medical assistants	Patient satisfaction	138	456	1082	"="
Rao, K.D. et al., (2013b)[89]	India	Primary care	Physicians	AYUSH and medical assistants	Health worker knowledge	40	146	NA	"="
Sharma, V. et al. (2015)[91]	US	Maternal and Child Health	Physicians	Nurses and physician assistants	Health worker knowledge	1	35	NA	"="
Vasan, A. et al. (2009)[92]	Uganda	HIV	Physicians	Nurses and clinical officers	Performance	12		521	"="
Repeated Cross Section Study									

Hoque, D.E. et al. (2013)[93]	Bangladesh	Primary care	Paramedics with 4 years of pre-service training or MA/SACMOs	Lower-level provider with only 18 months of pre-service training	Performance	19		175	"-"
Prospective Cohort Studies									
Bedelu, M. et al. (2007)[94]	South Africa	HIV	Physicians	Nurses	Patient outcomes	13		1025	"="
Brennan, A.T. et al. (2011)[95]	South Africa	HIV	Physicians	Nurses	Patient outcomes	3	Unclear	2,772	"="
Buwembo D.R., et al. (2012)[96]	Uganda	HIV	Physicians	Clinical officers	Patient outcomes		14	5152	"+"
Chilopora, G. et al. (2007)[97]	Malawi	Surgery	Medical Officers	Clinical officers	Patient outcomes	38		2131	"="
Frajzyngier, V. et al. (2014)[98]	Kenya	HIV	Clinical officers	Nurses	Patient outcomes	11	26	2,192	"="
Jejeebhoy, S.J. et al. (2011)[99]	India	Maternal and Child Health	Physicians	Nurses	Patient outcomes + satisfaction	5	20	897	"="
Long, L. et al. (2011)[100]	South Africa	HIV	Physicians	Nurses	Patient outcomes	2		2848	"+"
McCord C. et al. (2009)[101]	Tanzania	Surgery	Medical Officers	Assistant Medical Officers	Patient outcomes	14		1134	"="
McGuire, M. et al. (2013)[102]	Malawi	HIV	Clinical officers	Nurse practitioners	Patient outcomes	11		10112	"="
Mutabazi, V. et al. (2014)[103]	Rwanda	HIV	Physicians	Nurses	Patient outcomes	1		147	"-"
Sherr, K.H. et al. (2010)[104]	Mozambique	HIV	Physicians	Medical Technicians	Patient outcomes	2	52	5892	"=/+"
Weigel, R. et al. (2012)[105]	Malawi	HIV	Clinical officers	Nurse practitioners	Performance	1	7	367	"="
Retrospective Cohort Studies									
Assefa, Y. et al. (2012)[106]	Ethiopia	HIV	Physicians	Nurses and health officers	Patient outcomes	55		7451	"+/-"

Babigumira, J.B. et al. (2011)[107]	Uganda	HIV	Physicians	Pharmacists	Patient outcomes	1		829	"="
Beard, J.H. et al. (2014)[108]	Tanzania	Surgery	Physicians	Clinical officers	Patient outcomes	7	69	1392	"="
Federman, D.G. et al., (2005)[109]	US	Non-Communicable illness	Physicians	Resident, mid-level practitioner	Patient outcomes	8	113	19660	"="
Gessessew A., et al. (2011)[110]	Ethiopia	Surgery	Physicians	Health officers	Patient outcomes	13	15	2835	"="
Jeanmonod, R. et al. (2013)[111]	US	Emergency Medicine	Physicians	Nurse and physician assistant	Patient satisfaction	1		201	"-"
Kouanda, S. et al. (2014)[112]	Burkina Faso	Surgery	Physicians	Clinical officers	Patient outcomes	10		300	"-"
Monyatsi, G. et al. (2012)[113]	Botswana	HIV	Physicians	Nurses	Performance	1	13	1576	"="
Tyson, A.F. et al. (2014)[114]	Malawi	Surgery	Physicians	Clinical officers	Patient outcomes	1	26	1004	"="
Wallace, A.E., et al. (2006)[115]	US	Non-Communicable illness	Physicians	Nurse and physician assistant	Performance			472	"+"
Randomized controlled trials									
Begley, C. et al. (2011)[70]	Ireland	Maternal and Child Health	Physicians	Midwives	Patient outcomes	2	Unclear	1,653	"="
Chan, D. et al. (2009)[71]	UK	Surgery	Physicians (General practitioners)	Nurse practitioners	Patient outcomes			175	"+"
Dierick-van Daele, A.T.M. et al. (2009)[72]	Holland	Primary care	Physicians (General practitioners)	Nurse practitioners	Patient outcomes + satisfaction	15	62	1501	"="
Du Moulin et al. (2007)[73]	Holland	Non-Communicable illness	Physicians	Nurses	Patient outcomes + satisfaction		28	45	"="

Grimsrud, A. et al. (2014)[74]	South Africa	HIV	Physicians	Nurses	Patient outcomes	2	Unclear	5746	"=/-"
Houweling et al. (2009)[75]	Holland	Non-Communicable illness	Physicians	Nurses	Patient outcomes + satisfaction	2		84	"=/+"
Joshi, R. et al (2012)[76]	India	Non-Communicable illness	Physicians	Non physician health workers (NPHWs)	Performance	44		490	"="
Kiweewa, F.M. et al. (2013)[77]	Uganda	HIV	Physician	Nurses	Patient outcomes	1		85	"="
Kuethe M. et al. (2011)[78]	Holland	Non-Communicable illness	Physicians (General practitioners) or pediatricians.	Nurses	Patient outcomes	19		107	"=/-"
Rushforth, H. et al. (2006)[79]	UK	Surgery	Physicians (junior)	Nurse practitioners	Performance	1	35	595	"="
Sanne, I. et al. (2010)[80]	South Africa	HIV	Physicians	Nurses	Patient outcomes	2		812	"="
Voogdt-Pruis, H. et al. (2010)[81]	Holland	Non-Communicable illness	Physicians (General practitioners)	Nurse practitioners	Patient outcomes	6	31	701	"=/+"
Warriner I. et al. (2006)[82]	South Africa and Vietnam	Maternal and Child Health	Physicians	Physician assistants and midwives	Patient outcomes	8	25	2894	"-"
Warriner I. et al. (2011)[83]	Nepal	Maternal and Child Health	Physicians	Nurses and midwives	Patient outcomes	5		1032	"="

Chapter 3: (Paper 1) Task-shifting primary care to non-physician clinicians in Nigeria

ABSTRACT

Background: Within a context of worldwide efforts to avert a human resources for health crisis, Nigeria has long implemented a task-shifting strategy whereby non-physician clinicians are charged with the delivery of public primary care.

Methods: This study compares the knowledge of Medical Officers and non-physician clinicians who regularly deliver outpatient consultations in public primary care facilities across 12 Nigerian states. Non-physician clinicians were defined as Community Health Officers (CHOs), Nurse Officers, Nurse Midwives, Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs). We assessed 4,138 health workers using clinical vignettes for three child and two adult hypothetical patients suffering from illnesses commonly seen at primary health facilities and of public health importance. Facility-level fixed effects models were used to compare health worker knowledge of the consultation process guidelines for these illnesses, the health worker's diagnostic accuracy and their knowledge of treatment guidelines.

Results: Overall findings from this analysis point to small, albeit significant differences in the knowledge of consultation process clinical guidelines between Medical Officers and non-physician clinician cadres, significant differences in diagnostic accuracy for CHEWs and JCHEWs but not other cadres, and no significant differences in knowledge of treatment guidelines between these cadres. These findings, however, fall within a context of low overall knowledge. We find that although gender and experience of a health worker have no large or significant effects on our three health worker knowledge outcomes of interest, the number of non-

essential, additional, questions asked through the vignette interview is significantly positively correlated with knowledge of primary care.

Conclusion: Small or no differences between Medical Officer and non-physician clinician knowledge, suggests non-physician clinicians can potentially provide the same quality of primary care as Medical Officers. Our findings also highlight the need for overall improvements in health worker knowledge across Nigeria as well as the important role of an "intrinsic ability/motivation" on this knowledge.

INTRODUCTION

A world-wide human resources for health crisis has stimulated a call for further investment in human resource training and a search for alternative health service delivery models to fill large existing service delivery gaps [2,66]. The overall lack of trained health workers and difficulties in posting and retaining highly trained health workers to rural areas for the provision of primary health care, has led a number of countries to pragmatically shift their attention to the creation of new, or the strengthening of existing, non-physician clinician programs [6,30]. Non-physician clinicians are an important source of health care in many sub-Saharan African countries [6].

Non-physician clinicians encompass a wide variety of cadres and can be defined as health care providers that are not a medical doctor or physician nor a lay community health worker, but provide clinical care in the community, primary care facility or hospital [6]. Often called mid-level providers, this group of health workers includes clinical officers, medical or physician assistants, nurse clinicians or officers [6]. Commonly with post-secondary school training of 1-3 years, non-physician clinicians have been tasked with the delivery of basic primary care, minor surgeries, obstetrics [6,29] and in some cases, more specific tasks such as the provision of antiretroviral therapy to HIV/AIDS patients [128], or the screening and management of patients with non-communicable illnesses [23]

As a response to a chronic shortage and an urban-rural maldistribution of physicians, since the 1970's, Nigeria has implicitly implemented a wide reaching task-shifting strategy where non-physician clinicians have been trained to provide care in, and manage primary health facilities [37]. Community Health Officers (CHOs), Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs) are trained by state-level schools or

colleges of Health Technology [58] for four, two and one year, respectively, to deliver primary health care services [48]. At the health facility, with the support of available nurses and lower-level health worker cadres, CHOs, CHEWs and JCHEWs give consultations, write prescriptions and perform basic treatments as guided by 'National Standing Orders' [61]. These clinical guidelines act as a simple and accessible guide for non-physician clinicians in the identification and treatment of patients with common, basic illnesses, as would be provided by a fully trained physician [37]. In August of 2014, the Nigerian Federal Government approved a task-shifting and task-sharing policy that has made official and further expanded the essential role of CHOs, CHEWs, JCHEWs and nurses in the delivery of primary care [36].

Although often of limited quality, available evidence from across the world suggests that non-physician clinicians can perform a number of specific tasks as well as physicians [23,28–30,129,130]. There is, however, very little evidence on the ability of these mid-level cadres to identify and treat basic illnesses at the primary care level as compared to physicians [72,86,89,93]. To our knowledge, there has not been a study as of yet, that compares non-physician clinician knowledge or performance to that of physicians in Nigeria.

With this study we sought to compare the (i) knowledge of consultation process clinical guidelines, (ii) diagnostic accuracy, and (iii) knowledge of treatment guidelines for five basic illnesses (diarrhea, pneumonia, diabetes mellitus, TB and malaria), between Medical Officers and non-physician clinicians who regularly deliver primary care in Nigeria. We defined non-physician clinicians as CHOs, Nurse Officers, Nurse Midwives, CHEWs and JCHEWs for this analysis.

METHODS

Sampling

This study uses the World Bank's Service Delivery Indicators cross-sectional survey data collected from public sector, primary care facilities in twelve Nigerian states between July 2013 and January 2014. Using the official Federal Government list of public health facilities in Nigeria, facilities were stratified by state and urban/rural status. A total representative number of 75-100 facilities were then, randomly selected from each strata for a total of 150-200 from each state. In each facility, health workers who reported providing outpatient consultations more than once per week were selected for the health worker knowledge interview. In facilities with less than 10 eligible health workers, all health workers present in the facility on the day of the survey were interviewed. In facilities with more than 10 eligible health workers, 10 health workers were randomly selected. A total of 4,154 health workers from 2,113 primary care facilities across 12 states are selected for the study, 16 (less than 1%) refused to participate.

This sample is representative of all public primary care health workers who regularly provide outpatient consultations in the 12 Nigerian states included in this study. Inverse probability weights were calculated, and used for each facility and individual health worker. The probability of selection of each health worker was estimated as follows: (1) we estimated the probability of selection for each facility within each strata in the sampling frame, (2) we estimated the probability of selection of each health worker using the roster of health workers who reported regularly providing outpatient consultations in each facility and (3) we multiplied the probability of selection of the facility with the probability of selection of the health worker. Probabilities of selection were calculated to account for facility and health worker replacements where necessary.

Assessing Health Worker Knowledge

Health worker knowledge was assessed using clinical vignettes for seven standardized cases, where one enumerator acted as a patient presenting with a basic set of symptoms, and a second, recorded health worker questions, diagnoses, laboratory and treatment recommendations in a standardized questionnaire [89,123,131,132]. The clinical vignettes used in this study were originally developed by a team of World Bank experts for the pilot implementation of the Service Delivery Indicator survey in Senegal and Tanzania [38] and were again reviewed and validated, to fit the Nigerian context and clinical guidelines in 2013.

The five clinical vignettes are structured and delivered in a similar manner. Before the interview began, enumerators explained the interview process, recorded basic health worker information and performed a demonstration of a clinical vignette where one acted as the interviewer and the other as the health worker. The health worker was encouraged to ask any questions of clarification and provide their consent to proceed. For each hypothetical case, the enumerator, acting as the patient, presented him/herself, mentioning basic symptoms and the reason for seeking care. The pneumonia case for example, begins as follows: "Good morning (afternoon) doctor. I am the mother of this 5 year-old girl. Her name is Sia. She has a cough." Following the introduction of the hypothetical case, the health worker asked any questions that are relevant for him/her to reach a diagnosis and treatment. The questionnaire is designed for the "patient" enumerator to provide predefined answers to the health worker's questions. The health worker can verbally perform a physical examination by asking such questions as the temperature, for which the standardized response would be "38.5°C". All health workers were asked to give a diagnosis and recommend a treatment for each hypothetical case. The "observer" enumerator recorded all questions asked by the health worker for each hypothetical case. The questionnaire included the complete set of questions necessary to determine a

presumptive diagnosis and treatment recommended as outlined in the national clinical guidelines. The questionnaire also included, approximately twice as many, commonly asked, non-essential questions that can be relevant or irrelevant to the diagnosis and treatment of the case.

As is outlined in Table 4 below, the five cases in the order they were presented to the health worker are: (1) a 13 month old boy with acute diarrhea and severe dehydration, (2) a five year-old girl with pneumonia, (3) a 48 year-old man with type II Diabetes, (4) a 40 year-old man with Pulmonary Tuberculosis and (5) a four year-old boy with malaria and anemia. In an attempt to cover the breadth of knowledge required to deliver primary care, these five cases represent illnesses commonly seen by primary health care workers in Nigeria (and many other low- and middle-income countries), communicable and non-communicable illnesses of high public health concern as well as illnesses of children and adults.

All health workers were asked to complete all cases. Sixteen health workers that did not report their cadre and 27 health workers who did not complete all cases were excluded from this analysis (1% of the total sample): their characteristics were not significantly different from health workers who were included.

Table 4: Vignette case definitions, essential questions and treatment as defined in National Standing Orders

Diagnosis-case presentation	National Standing Orders Definition [4]
Acute diarrhea with severe dehydration- 13 month old boy with diarrhea	***Severe condition*** Main symptoms: Frequent watery stool with weakness, with or without vomiting Examination: Lethargic or unconsciousness, sunken eyes, drinks poorly or unable to drink, skin pinch goes back very slowly Treatment: ORS by mouth if child can drink AND 100ml/kg Ringer's Lactate Solution, first 30ml/kg in 30 min and then 70ml/kg in 2.5 hours. Reassess every 1-2 hours.
Pneumonia- 5 year old girl with a cough	***Moderate condition, suspect Pneumonia*** Main symptoms: Cough with fast breathing Examination: fast breathing (>40 breath/min), no chest in-drawing, temp >37C, chest not clear, difficulty breathing (danger sign), inability to suck/drink (danger sign) Treatment: Cotrimoxazole 1 tab (480mg) bd x5/7 OR Amoxicillin 250mg/10mls qds x 5. Give Paracetamol if temp is >37.5C, ½ tab or 250mg qds x5 days. Ask parent to bring child back in 2 days.
Diabetes Type II - 48 year old man feeling weak, without energy and is often hungry	***Severe condition, suspect Diabetes*** Main symptoms: Passing a lot of urine, getting up more than 4 times at night to pass large quantities of urine but without pain, feel very thirsty and drinks a lot of water/fluid, loss of weight Examination: General weakness, examine urine for increased sugar and blood Treatment: Refer to hospital (in analysis, if Medical Officer: Oral Hypoglycemic or insulin when hypoglycemic are not effective)
Pulmonary Tuberculosis- 40 year old man suffering from fever and cough for some time	***Moderate condition, suspect Pulmonary Tuberculosis*** Main symptoms: Cough of more than 3 weeks duration with or without chest pain with weight loss and shortness of breadth Examination: Coughing, sputum may or may not have blood, weight loss, breathlessness Treatment: Request for 3 sputum examinations, if at least 2 of 3 are positive, treat for pulmonary TB. Expectations of treatment depend on the receipt of specific TB training, not on specific cadres: if trained on TB management and have necessary drugs: First 2 months daily supervised: combined tablet of RHZE (150mg + 75mg + 400mg + 275mg). Daily for 6 months: combined tablet of EH(400mg+150mg) OR supervised for 4 months: combined tablet of RH (150mg + 75mg). If not trained, refer to the Clinic.
Malaria with Anemia - 4 year old boy with fever for some time that is now worse	***Severe Condition*** Main symptoms: Fever with any of the following: Vomiting, unable to feed, convulsions or history of convulsions Examination: Temp 37.5 C or above with any of the following: neck stiffness, change in alertness, convulsions, bulging fontanelle, moderate dehydration, lethargic Treatment: Continue feeding. Paracetamol 250mg stat. Artemether-Lumefantrine 2 tablets twice daily for 3 days OR Artesunate+Amodiaquine 50mg/135mg one tablet once daily for 3 days. Oral Chloramphenicol 1.2ml.

[4] NPHDA. 2010. National Standing Orders for Community Health Officers/Community Health Extension Workers.

Health worker knowledge of the management of each case was assessed using the *Nigerian 2010 National Standing Orders for Community Health Officers and Community Health Extension Workers*, as the minimum desired standard of care. The three outcome measures of overall health worker knowledge of primary care practices were constructed in two steps. First, for each of the 5 cases, we generated three measures of knowledge: (i) consultation process clinical guidelines (a continuous variable for the % of essential history and physical examination questions asked), (ii) diagnostic accuracy (a dichotomous variable for correct/incorrect diagnosis) and, (iii) treatment guidelines (a dichotomous variable for full correct/incorrect treatment). In a second step, overall measures of (i) the average percentage of essential questions in the clinical guidelines for the consultation process across the five cases, (ii) the percentage of five cases with a correct diagnosis and (iii) the percentage of five cases with a full correct recommended treatment were also calculated and used as the main outcome measures in this analysis.

Multivariate linear regression analyses were used to compare the knowledge of Medical Officers with that of non-physician clinician cadres, for each of the three overall knowledge outcome measures. Weighted ordinary least squares (OLS) regressions with facility-level clustered robust standard errors and facility-level fixed effects models were used in the analysis. Based on existing literature (and variation across cadres in our sample), but restricted by available survey measures, we understood health worker knowledge as a function of individual health worker and facility-level characteristics. We included dummy variables for 10 different health worker cadres or general groups of cadres using Medical Officers as the reference cadre in our models. Medical Officers are physicians with four of more years of clinical training and are used as our point of comparison as the standard of training for clinical care in a task-shifting strategy. Although included as individual dummy variables, we define

non-physician clinicians as CHOs, CHEWs, JCHEWs, Nurse Officers and Nurse Midwives. We also included environmental health officers/assistants, community health assistants, health attendants/auxiliary nurses and dental officers/nurses/technicians, as a way to validate our measures, hypothesizing that these lower level cadres that have not received training in the delivery of primary care ought to perform less well in our measures of knowledge than the higher-level cadres.

Aside from health worker cadre (our independent variable of interest) we included controls for gender, years of experience as a health worker and a variable for the total number of non-essential questions the health worker asked across the five vignette cases. We found a high correlation (77.5%) between the variables of age and years of experience and chose to avoid multicollinearity in our models by including only years of experience, which we deemed to be theoretically more relevant to our knowledge models: the variable was included as a spline at 8 years to ensure linearity of our models. Furthermore, more outgoing and talkative health workers could naturally ask more questions and by chance ask more essential consultation questions as outlined in the clinical guidelines. Therefore, we included, as a proxy, a variable for the number of non-essential questions asked by the health worker across the five vignette cases. This represented the number of questions included in the questionnaire that the health worker asked, which were not essential to the consultation process for the case as outlined by the standing orders; these questions could be correct but unnecessary or incorrect altogether. Non-essential questions that were not included in the questionnaire were recorded as notes, however unlike the non-essential questions included in the questionnaire, we found these to be correlated with the individual enumerator undertaking the interview, and hence did not consider this as a reliable measure.

RESULTS

Sample characteristics

We assessed the knowledge of a total of 4,138 health workers that represent a population of approximately 42,000 health workers who regularly perform outpatient consultations at public primary health facilities in 12 Nigerian states (Table 2). We found that across the 12 states included in our sample, the vast majority (87.6%) of health workers that provide public primary care are non-physician clinicians, 2.6% are Medical Officers and 9.9% are lower-level cadres who have not been trained to provide this type of care. This weighted proportion of health worker cadres varies widely across states, however. Medical Officers represent 0.2% of this workforce in states like Bauchi and Taraba while representing over 25% in Bayelsa. The proportion of non-physician clinicians varies between 69% in Bayelsa and 98% in the state of Niger while untrained health care providers account for less than 1% of the workforce in Niger but over 25% in the state of Osun. With some variation across cadres, on average, health workers in these 12 states are just over 40 years old, have 13.6 years of experience, are primarily female (71.6%), are posted to health centers (66.8%) as opposed to health clinics (23.4%) or health posts/dispensaries (9.8%) and just over half can be found working in rural areas (57.2%).

Table 5: Health Worker Sample Characteristics by cadre

	Medical Officer	CHO	Nurse Officer	Nurse Midwife	CHEW	JCHEW	Env Hlth Off/Ass	Comm Hlth Ass	Hlth Att/AuxNurse	Dental Off/Nur/Tech	Total
N	115	256	497	169	1,891	802	110	93	168	37	4,138
Wtd prop	2.6	5.9	12.7	4.7	44.2	20.1	2.6	2.2	4.4	0.7	100
Age (years) (CI)	40.5 *(36.3-44.7)*	45.0 [a] *(43.7-46.3)*	45.2 [a] *(44.1-46.2)*	36.8 *(34.7-38.9)*	40.4 *(39.9-40.8)*	35.7 [a] *(34.9-36.4)*	33.6 [a] *(32.1-35.2)*	41.1 *(39.3-42.9)*	39.1 *(37.6-40.7)*	34.9 *(31.3-38.6)*	40.5 *(36.3-44.7)*
Experience (years) (CI)	13.6 *(9.6-17.6)*	20.7 [a] *(19.0-22.3)*	19.1 [a] *(17.8-20.4)*	9.2 *(6.4-11.9)*	14.9 *(14.4-15.5)*	10.5 *(9.8-11.2)*	7.9 [a] *(6.8-8.9)*	15.4 *(13.3-17.5)*	12.3 *(10.8-13.8)*	9.9 *(6.4-13.4)*	13.6 *(9.5-17.7)*
Female (%)	20.7	62.3	86.4	99.8	71.2	65.4	37.6	81.4	89.1	70.9	71.6
Rural (%)	13.5	51.0	40.9	72.4	57.9	69.1	70.4	50.8	58.4	41.5	57.2
Facility Type											
Hlth Po/Di	3.0	6.5	2.4	3.9	10.9	12.0	17.8	20.6	15.4	7.7	9.8
Hlth Clin	35.0	15.4	20.7	10.6	26.0	28.0	22.1	11.6	6.7	36.0	23.4
Hlth Ctr	62.0	78.1	76.8	85.5	63.1	60.0	60.1	67.8	77.9	56.3	66.8
(total)	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
State											
Anambra	1.2	2.7	26.7	8.4	47.7	9.5	0.1	1.0	2.6	0.1	100
Bauchi	0.2	3.7	7.5	0.7	42.7	29.3	14.4	0.7	0.8	0.0	100
Bayelsa	25.9	9.6	8.7	9.6	28.4	12.4	0.2	0.2	0.3	4.8	100
Cross River	1.4	15.3	12.6	2.9	53.4	12.9	0.0	0.7	0.6	0.2	100
Ekiti	2.8	4.1	17.9	3.3	52.2	9.8	0.1	3.7	3.4	2.8	100
Imo	1.3	3.3	18.0	13.6	30.4	14.4	3.4	4.1	11.5	0.0	100
Kaduna	4.7	11.6	14.0	2.6	46.8	18.6	1.2	0.6	0.0	0.0	100
Kebbi	0.3	2.6	3.1	6.4	48.3	26.1	9.4	0.8	0.4	2.7	100
Kogi	0.8	7.0	12.4	0.0	53.6	21.1	0.4	3.0	1.0	0.8	100
Niger	1.5	2.4	4.8	1.8	51.7	37.2	0.0	0.1	0.6	0.0	100
Osun	4.0	7.5	17.2	2.6	31.8	11.8	0.0	6.7	17.4	1.0	100
Taraba	0.2	2.4	11.1	3.8	47.3	24.1	2.6	3.2	4.3	1.1	100

Note: Averages and proportions presented are weighted for the inverse probability of selection of each health worker across the different cadres. [a] t-test difference with Medical Officers $p<0.05$

Cadre differences across outcome measures

Simple weighted mean comparisons of consultation process clinical guidelines, diagnostic accuracy and treatment guideline knowledge show low overall knowledge as well as significant differences between Medical Officers and non-physician clinicians. Medical Officers ask 1-2 (of approximately 4-6) more consultation questions as recommended by the clinical guidelines and are able to diagnose and adequately treat one more of the five cases presented (Table 6). Medical Officers on average, ask 56.8% of the physical examination and history taking questions recommended for a consultation by the clinical guidelines, significantly more than CHOs (35.1%), Nurse Officers (35.7%), Nurse Midwives (34.3%), CHEWs (29.2%) and JCHEWs (27.2%). Similarly, Medical Officers accurately diagnose 72.2% of presented cases, significantly more than CHOs (53.3%), Nurse Officers (57.1%), Nurse Midwives (56.9%), CHEWs (46.4%) and JCHEWs (43.1%). The percentage of cases for which treatment was adequately prescribed, is much lower than the percentage of cases accurately diagnosed, for all cadres. Medical officers prescribed the full recommended treatment to less than half (43.5%) of presented cases, significantly more than CHOs (25.1%), Nurse Officers (27.0%), Nurse Midwives (26.2%), CHEWs (20.6%) and JCHEWs (19.3%). Across the three measures, lower level cadres without primary care consultation training; present lower scores than non-physician clinician cadres.

Table 6: Consultation Knowledge Outcomes by Case and Cadre

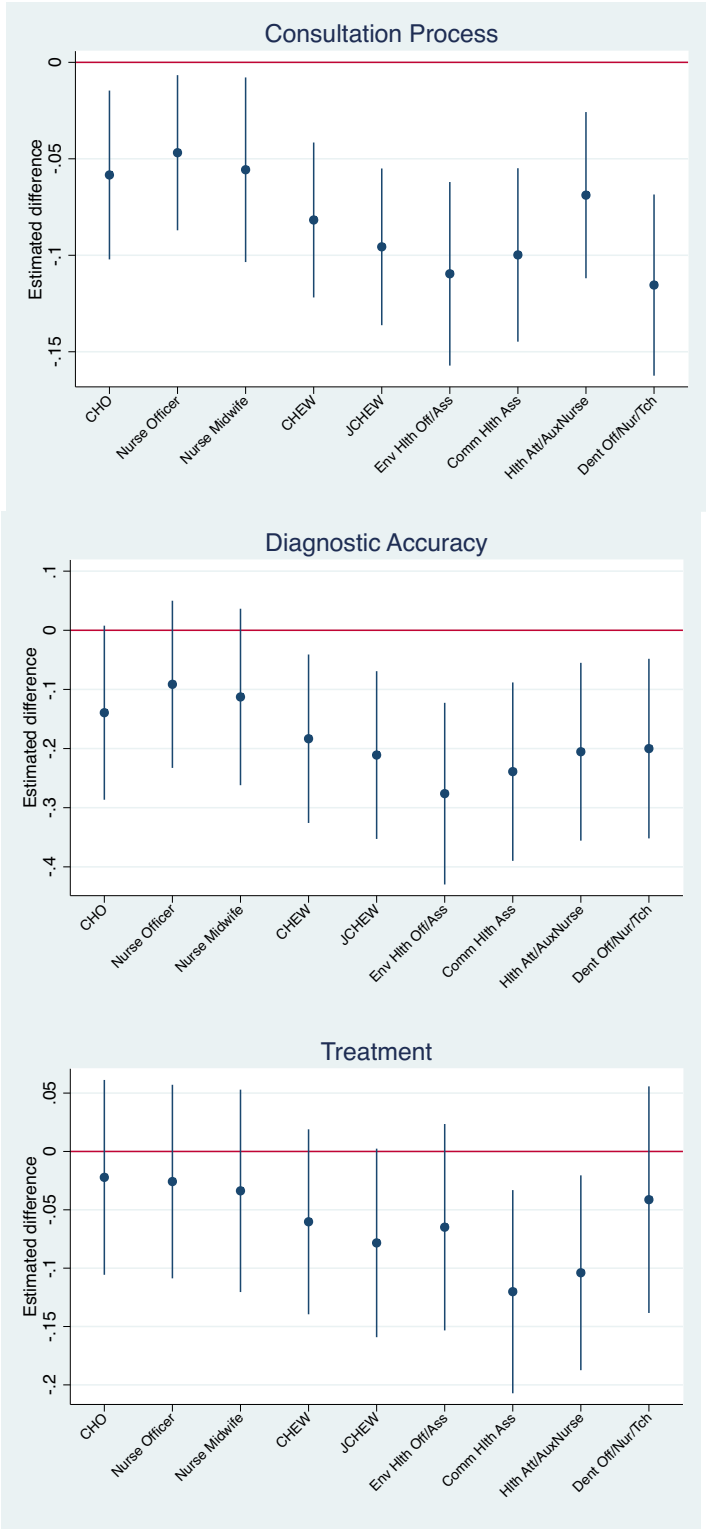
	N	Consultation Process[1]		Diagnosis[2]		Treatment[2]	
	N	***mean***	***CI***	***%***	***CI***	***%***	***CI***
Cadre							
Medical Officer	106	56.8	(50.6-63.0)	72.2	(64.6-79.7)	43.5	(36.3-50.8)
CHO	253	35.1 [a]	(32.2-38.1)	53.3 [a]	(48.2-58.3)	25.1 [a]	(22.0-28.2)
Nurse Officer	494	35.7 [a]	(33.6-37.8)	57.1 [a]	(53.7-60.5)	27.0 [a]	(24.3-29.8)
Nurse Midwife	168	34.3 [a]	(30.8-37.8)	56.9 [a]	(51.6-62.2)	26.2 [a]	(20.7-31.7)
CHEW	1,886	29.2 [a]	(28.2-30.3)	46.4 [a]	(44.9-47.8)	20.6 [a]	(19.4-21.9)
JCHEW	799	27.2 [a]	(25.9-28.4)	43.1 [a]	(40.8-45.4)	19.3 [a]	(17.5-21.1)
Env Hlth Off/Ass	110	26.0 [a]	(22.1-29.8)	43.4 [a]	(35.8-51.0)	18.1 [a]	(13.0-23.3)
Comm Hlth Ass	92	19.8 [a]	(16.1-23.5)	31.3 [a]	(25.7-36.8)	13.8 [a]	(10.0-17.7)
Hlth Att/AuxNurse	167	18.3 [a]	(15.8-20.8)	30.3 [a]	(26.7-33.9)	12.0 [a]	(9.4-14.6)
Dental Off/Nur/Tech	36	24.0 [a]	(17.6-30.4)	47.0 [a]	(37.6-56.3)	21.9 [a]	(16.6-27.2)
All	4,111	30.1 [a]	(29.4-30.8)	47.5 [a]	(46.4-48.6)	21.7 [a]	(20.8-22.6)

Note: Means presented here are weighted for the inverse probability of selection of each health worker. [1:]The mean for consultation process is calculated as the average percentage history taking and physical examination questions asked by each type of health worker, across 5 cases. [2:] For each cadre, the % correct diagnoses and the %correct treatment is calculated as the average percentage of the 5 cases that was correctly diagnosed or treated by each type of health worker. [a:] t-test difference of outcome mean compared to Medical Officers $p<0.05$

Regression Models

Observed differences in knowledge between Medical Officers and non-physician clinicians could be confounded by health worker and facility characteristics. To control for these differences, we used facility-level fixed effects models (with robust standard errors), to explore the differences, between Medical Officers and non-physician clinicians, across our three knowledge outcomes of interest. We find non-physician clinicians have statistically significantly lower knowledge of the consultation process guidelines than Medical Officers. However, CHEWs and JCHEWs, but not CHOs, Nurse Officers and Nurse Midwives, have lower diagnostic accuracy than Medical Officers and all non-physician clinicians show an equal knowledge of treatment guidelines when compared to Medical Officers (Figure 4). The sections below outline our regression model findings for each outcome.

Figure 4: Estimated difference in consultation process, diagnostic accuracy and treatment knowledge across cadres as compared to Medical Officers.



Note: Estimated values are adjusted for health worker gender, experience, number of non-essential question asked and facility-level characteristics. Zero value represents no difference when compared to Medical Officers. See Table 7 for specific values.

Knowledge of consultation process clinical guidelines

After controlling for individual health worker and facility-level characteristics, we find that Medical Officers show slightly, yet statistically significantly, more knowledge of the consultation process clinical guidelines for primary care than non-physician clinicians (Table 4). Using a fixed effects model to control for health worker characteristics and facility-level factors, we find that CHOs, Nurse Officers, Nurse Midwives, CHEWs and JCHEWs ask an average of 5.8, 4.7, 5.6, 8.2, and 9.6% less recommended consultation questions than Medical Officers, respectively (model 1). We find that female health workers show slightly but significantly lower knowledge of the consultation process guidelines than male health workers, while health workers who ask more non-essential questions display significantly greater knowledge. A similarly specified random effects model shows very similar results (not shown). A Hausman test comparing the two models (chi2=10.97, p=0.6134) suggests that we cannot reject the possibility that facility level characteristics are in fact correlated with health worker characteristics included in our model. From our fixed-effects model we find that facility level effects account for 51.6% of the variation in the model, suggesting that the facility to which a health worker is assigned, has an important effect on their knowledge of the consultation process guidelines for primary care.

Diagnostic accuracy

We find no statistical difference in the diagnostic accuracy of CHOs, Nurse Officers and Nurse Midwives, compared to Medical Officers, after controlling for health worker and facility-level characteristics (model 2). The diagnostic accuracy of CHEWs and JCHEWs is significantly lower than that of Medical Officers, however. CHEWs and JCHEWs give a correct diagnosis to 18.3% and 21.1% less hypothetical cases than Medical Officers; this means they are able to diagnose approximately one case less (of 5) than Medical Officers are. As in the models for the knowledge

of consultation process guidelines, we find that diagnostic accuracy increases with the total number of non-essential questions asked by a health worker, even after controlling for health worker and facility-level characteristics. A Hausman test comparing equally specified, fixed effects and random effects (not shown) models confirms (chi2=36.37, p=0.0005) that we can reject the possibility that facility level effects are correlated with the health worker characteristic variables included in the models and further supports our fixed-effects model estimates as more efficient and consistent. From the fixed effects model, we find that facility-level effects account for 59.5% of the variability in health workers' diagnostic accuracy.

Treatment Guidelines

We find no significant difference in the knowledge of treatment guidelines between Medical Officers and non-physician clinicians when controlling for health worker and facility-level characteristics (model 3). Again, and more surprisingly, we find that knowledge of treatment guidelines increases as the number of non-essential questions asked increases, even after controlling for health worker and facility-level characteristics. A Hausman test comparing the facility-level fixed and random effects models confirms (chi2= 24.86, p=0.0360) that our fixed effects estimates are most efficient and consistent, further supporting our conclusion of no difference in the knowledge of treatment guidelines between Medical Officers and non-physician clinicians. We find that 52.4% of the variation in the fixed effects model is due to facility-level characteristics.

Table 7: Adjusted difference in consultation process, diagnostic accuracy and treatment knowledge across health worker cadres, compared to Medical Officers

VARIABLES	(1) Consultation Process	(2) Diagnostic Accuracy	(3) Treatment
Cadre			
Medical Officer	[ref]	[ref]	[ref]
CHO	-0.0584***	-0.139*	-0.0222
	(0.0223)	(0.0750)	(0.0426)
Nurse Officer	-0.0468**	-0.0914	-0.0258
	(0.0205)	(0.0721)	(0.0423)
Nurse Midwife	-0.0557**	-0.113	-0.0338
	(0.0244)	(0.0761)	(0.0442)
CHEW	-0.0817***	-0.183**	-0.0603
	(0.0205)	(0.0726)	(0.0404)
JCHEW	-0.0956***	-0.211***	-0.0784*
	(0.0207)	(0.0723)	(0.0412)
Env Hlth Off/Ass	-0.110***	-0.276***	-0.0649
	(0.0243)	(0.0783)	(0.0451)
Comm Hlth Ass	-0.0998***	-0.239***	-0.120***
	(0.0229)	(0.0769)	(0.0444)
Hlth Att/AuxNurse	-0.0688***	-0.205***	-0.104**
	(0.0220)	(0.0767)	(0.0426)
Dent Off/Nur/Tch	-0.115***	-0.200***	-0.0413
	(0.0239)	(0.0774)	(0.0495)
Gender			
Female	-0.0153**	-0.0160	-0.0140
	(0.00670)	(0.0144)	(0.0123)
Experience			
<8 yrs experience	0.000986	0.00270	0.00313
	(0.00139)	(0.00283)	(0.00261)
8+ yrs experience	-0.00185	-0.00383	-0.00288
	(0.00162)	(0.00321)	(0.00296)
Non-essential questions			
Total non-ess Q	0.00939***	0.0100***	0.00300***
	(0.000475)	(0.00101)	(0.000802)
Total non-ess Q^2	-2.65e-05***	-3.72e-05***	1.52e-05*
	(4.34e-06)	(8.29e-06)	(8.78e-06)
Constant	0.112***	0.352***	0.132***
	(0.0244)	(0.0763)	(0.0435)
R-squared	0.559	0.259	0.185
Hausman test with OLS	(chi2=30.81, p=0.0036)	(chi2=46.95, p=0.0000)	(chi2=38.51, p=0.0002)
Hausman test with RE	(chi2=10.97, p=0.6134)	(chi2=36.37, p=0.0005)	(chi2= 24.86, p=0.0360)
Rho	0.5157	0.5950	0.5241
Observations	4,040	4,040	4,040
Number of facilities	2,086	2,086	2,086

Note: Facility-level fixed effects models. Values depict percentage point differences in knowledge of each outcome variable. See Annex for OLS and Random Effects Models. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

DISCUSSION

Overall findings from this analysis point to small, albeit significant differences in the knowledge of consultation process clinical guidelines between Medical Officers and non-physician clinician cadres, significant differences in diagnostic accuracy for CHEWs and JCHEWs but not other cadres, and no significant differences in knowledge of treatment guidelines between these cadres. Our findings suggest that all else being equal, non-physician clinicians know enough to provide comparable quality primary-level health services as compared to Medical Officers and might serve as a reliable alternative for staffing lower level, rural and remote facilities across the country. Although we find only small, if any differences in knowledge between non-physician clinicians and Medical Officers, we find this within a context of low overall levels of knowledge across all cadres. Findings from our different models suggest that there are a number of factors that affect health worker knowledge, which could be considered in the design or expansion of task-sharing policies.

Although often with limited health worker sample sizes, studies that have compared non-physician clinician performance in the delivery of primary care, to that of higher-level cadres have found mixed results [72,86,87,89,90,93]. A study that also used clinical vignettes to assess health worker knowledge of primary level care, comparing rural medical assistants and traditional Indian practitioners to physicians, found no significant differences in knowledge between these cadres [89]. Another study that used direct observation to assess health worker performance in the provision of IMCI services across four countries found mixed results: health workers with shorter duration of training in Brazil and Uganda, correctly managed a higher proportion of children compared to health workers with longer duration of training, in Tanzania those with longer duration of training managed a higher proportion of children while in Bangladesh, there

was no difference across cadres [86]. In Bangladesh, a study comparing the provision of IMCI case management by medical assistants with 4 years of training to family welfare visitors (a cadre with 18 months of training) found that a greater percentage of children received case management for all illnesses when cared for by the higher-level cadre [93]. Studies that have measured patient satisfaction with the provision of primary care have found that patients who received care from non-physician clinicians were equally [72,90] or more highly [87] satisfied than those who received care from physicians.

This is not the first study to find low overall health worker knowledge and adherence to clinical guidelines. Similarly to other studies that have assessed health worker knowledge of the delivery of primary care health services using vignettes [89,121,123,125,133–135], our study finds low knowledge of clinical guidelines for the consultation process, low diagnostic accuracy and low knowledge of treatment guidelines. Studies that have compared levels of knowledge using vignettes to health worker performance with observed consultations, in low and middle-income countries, have found a "know-do-gap" that seems to consistently show that health worker's performance is overestimated by their knowledge [132,134–137]. In light of a potential know-do-gap, the widespread, low health worker knowledge of clinical guidelines, identification and treatment of common, high mortality-causing illnesses points to even lower quality of primary care in the twelve Nigerian states included in this study, than what we are actually measuring.

There is variation in knowledge within all cadres in our study. We find, consistently for each of the outcomes in this analysis, that the number of years of experience a health worker has (regardless of their cadre), has no significant effect on their knowledge. Evidence from similar studies that have also used vignettes have seen contradictory effects of experience on knowledge or competence [123,124]. In our analysis, we also find that although female health

workers are slightly but significantly less knowledgeable of the consultation process guidelines than their male counterparts, there is no significant gender difference in diagnostic accuracy or knowledge of treatment guidelines. The majority of similar studies have not directly addressed the gender difference in the knowledge for health service provision, those that have, find conflicting results [89,123,132,138].

Overall, we find a significant positive correlation between each of the three outcomes of interest and the total number of non-essential questions that a health worker asks during the hypothetical consultation process. To our knowledge, this is the first study to explore the effect of this variable on health worker knowledge in primary care. The variable of the total number of non-essential questions asked, was defined as the total number of either relevant or irrelevant questions included in the questionnaire that were asked across the 5 cases presented in the vignettes. Although we have no way of confirming our hypothesis with the available data, we believe that this variable represents an intrinsic ability or motivation of a health worker that might enable them to consider a broader number of potential diagnoses, lead them to ask more questions about the case and to rule out other possible diagnoses. The positive correlation between this variable and treatment knowledge, further supports our hypothesis. We believe that although asking a greater number of questions could in fact increase the probability of asking the essential questions and could potentially, help the health worker reject any other possible diagnoses, it is less likely to be able to increase a health worker's probability of knowing the treatment guidelines. We hypothesize that health workers with this greater "intrinsic ability or motivation" could have studied or been more aware of the treatment guidelines than others of their same cadre, experience, gender and even those posted to similar facilities. Further research is needed to better understand the role of this factor on health worker knowledge and how it could be important to health worker selection and training. The

importance of this factor across each of our models suggests that this intrinsic ability could be as or more important than the health worker's formal training (reflected by their cadre) to the knowledge necessary for the provision of primary care.

CONCLUSION

Within a context of low overall knowledge, our findings suggest that non-physician clinicians in Nigeria have similar knowledge of clinical guidelines, more highly trained cadres (but not CHEWs and JCHEWs) have equal diagnostic accuracy and all cadres have equal knowledge of treatment guidelines when compared to physicians. Our results suggest that non-physician clinicians can potentially deliver equal quality primary care to that delivered by Medical Officers. However, the number of non-essential questions asked by a health worker is significantly positively correlated with each of the three knowledge outcomes, suggesting that a health worker's intrinsic ability is, together with their level of training, an essential determinant of their knowledge of primary care.

Chapter 4: (Paper 2) Task-shifting the treatment of childhood pneumonia to non-physician clinicians: do they know as much as doctors?

ABSTRACT

Background: As the country with the second highest total mortality from pneumonia among children under the age of five, Nigeria's strategies to tackle the disease are paramount to global efforts. The provision of timely and adequate treatment for this illness is highly reliant on a knowledgeable health workforce. As is the case for many other low-income countries, Nigeria faces a chronic shortage and maldistribution of physicians, and has come to rely on non-physician clinicians for much of its primary care.

Methods: We compared the knowledge for the treatment of childhood pneumonia between non-physician clinicians and Medical Officers who regularly perform outpatient consultations in public primary and secondary facilities across 12 Nigerian states. Non-physician clinicians were defined as Community Health Officers (CHOs), Nurse Officers, Nurse Midwives, Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs). We assessed the treatment knowledge of 4,767 health workers using a clinical vignette of a young child presenting with pneumonia symptoms. Using facility-level logistic fixed-effects models we compared health worker knowledge of consultation guidelines, diagnostic accuracy as well as each and all pneumonia treatment components recommended by the national clinical guidelines.

Results: We find that although Medical Officers have significantly greater knowledge of the consultation process guidelines and are better able to identify a case of pneumonia; they are equally or less likely to know to prescribe the full treatment to a child with this illness than are

non-physician clinicians. Our findings suggest that non-physician clinicians compare favorably with Medical Officers in their knowledge to prescribe recommended or effective antibiotics, equally or less likely to know to recommend paracetamol and less likely to know to recommend follow-up, as are Medical Officers, when treating a childhood case of pneumonia.

Conclusion: Non-physician clinicians have the potential to take on the task of treating patients with pneumonia as well or better than Medical Officers, however, strategies should focus on increasing overall knowledge for all cadres, including Medical Officers.

INTRODUCTION

In Nigeria, nearly 12 out of every 100 children born each year, die before their fifth birthday [43]. Approximately 15% of these deaths are caused by pneumonia, amounting to 120,000 children each year [43]. As the country with the second highest total mortality from pneumonia among children under the age of five (nearly 13% of all global deaths due to this illness each year), Nigeria's efforts to tackle this disease are paramount to all global efforts to combat the disease [139]. For young children, death from pneumonia can occur within three days of the onset of symptoms [140], hence, early care seeking, identification and treatment with antibiotics are key to efforts to reduce mortality [141].

Low care-seeking and low antibiotic treatment coverage are likely culprits of the high levels of pneumonia mortality in Nigeria [142]. The 2013 Demographic and Health Survey found that among children reporting symptoms of an acute respiratory infection (ARI), of which pneumonia is a common cause, advice from a health facility or provider was sought only for 34.5%, and 36.5% received some form of antibiotic treatment [143]. Preventive efforts cannot currently be relied on to drastically reduce the incidence of pneumonia in Nigeria. Immunizations rates against pneumonia are likely to be quite low: with a recent launch (December 2014) of the pneumococcal vaccine in the state of Kogi [144] and low overall immunization rates (DPT coverage of 38%) [143], it will take some time for the impact of the vaccine on the overall mortality from this illness to be observed. With slow advances towards prevention of the illness, concurrent efforts to improve the access and quality of care for children with this illness are paramount to a reduction in mortality.

As a response to a chronic shortage and maldistribution of physicians in rural areas, since the 1970's, Nigeria has trained Community Health Officers (CHOs), Community Health Extension

Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs) as non-physician clinicians. They are trained for four, two and one year, respectively [48], to provide care in, and manage primary health facilities [37]. Together with nurses, these non-physician clinicians make up the highest proportion (nearly 80%) of public primary and secondary health workers and are hence essential to the efforts to reduce pneumonia mortality. At the health facility, with the support of available nurses and lower-level health worker cadres, CHOs, CHEWs and JCHEWs give consultations, write prescriptions and perform basic treatments as guided by 'National Standing Orders' [61]. These clinical guidelines outline a number of history taking questions and physical examinations to determine a pneumonia diagnosis and to prescribe a recommended treatment as would be provided by a physician [37]. In August of 2014, with the approval of a task-shifting and task-sharing policy that has made official and further expanded the essential role of CHOs, CHEWs, JCHEWs and nurses in the delivery of primary care, the role of these non-physician clinicians in the reduction of pneumonia mortality has become ever more clear [36].

Very few studies over the past decade have assessed the performance of non-physician clinicians in the identification and treatment of a childhood case of pneumonia, within a package of primary care services, as compared to higher-level cadres. Available studies find mixed results. A study in Bangladesh, that compared Family Welfare Visitors with 18 months of training to Community Health Care Officers with 4 years of training found that that the children managed by the higher trained cadre received a complete IMCI assessment, including an assessment of pneumonia, more frequently than those managed by the lower-level cadre [93]. A multi-country study that compared lower and higher cadre health workers in the delivery of IMCI services (including pneumonia care) found that the proportion of children correctly managed by lower-level cadre health workers was greater in Brazil and Uganda, lower in

Tanzania and equal in Bangladesh, when compared to higher-level cadres [86]. Finally, a study, in India, that compared the clinical competence in the delivery of care for a number of illnesses that included childhood pneumonia, between physicians to non-physician clinicians found no difference between these cadres [89]. We are not aware of any studies that have focused their analysis solely on the shifting of pneumonia related tasks to non-physician clinicians.

With this study, we sought to assess the difference in knowledge of the treatment of pneumonia between Medical Officers and non-physician clinicians who regularly provide outpatient consultations in public primary and secondary health facilities in twelve Nigerian States. We defined non-physician clinicians as CHOs, Nurse Officers, Nurse Midwives, CHEWs and JCHEWs for this analysis.

METHODS

Sampling

For this analysis we used the World Bank's Service Delivery Indicators cross-sectional survey data collected from public sector, primary and secondary level facilities in twelve Nigerian states between July 2013 and January 2014. The sampling frame for the selection of facilities was the official Federal Government list of public health facilities in Nigeria. For sampling, facilities were stratified by state and urban/rural status. A total representative number of 75-100 facilities were then, randomly selected from each strata for a total of 150-200 from each state. In each facility, a roster of all health workers and their basic characteristics was created; health workers who reported providing outpatient consultations more than once per week were selected for the health worker knowledge interview. In facilities with less than 10 eligible health workers, all health workers present in the facility on the day of the survey were interviewed. In facilities with more than 10 eligible health workers, 10 health workers were randomly selected. A total of 5,103 health workers were selected to participate in the study, but

44 (less than 1%) refused to participate. A total of 5,080 health workers from 2,325 primary and secondary level facilities across 12 states are included in the study.

The sample of health workers included in this study is representative of all public primary and secondary level health workers who provide outpatient consultations more than once per week, in the 12 Nigerian states included in this study. We calculated inverse probability weights for each facility and individual health worker in order to adjust our estimates to the sampling strategy and be able to infer beyond our sample population. The probability of selection of each health worker was in three steps: first, we estimated the probability of selection for each facility within each strata in the sampling frame, secondly, we estimated the probability of selection of each health worker using the roster of health workers who reported regularly providing outpatient consultations in each facility and finally we multiplied the probability of selection of the facility with the probability of selection of the health worker. Probabilities of selection account for facility and health worker replacements where necessary.

Assessing Health Worker Knowledge

Health worker knowledge was assessed using clinical vignettes for seven standardized cases, where one enumerator acted as a patient presenting with a basic set of symptoms, and a second, recorded health worker questions, diagnoses, laboratory and treatment recommendations in the standardized questionnaire [89,123,131,132]. The clinical vignettes used in this study were originally developed by a team of World Bank experts for the pilot implementation of the Service Delivery Indicator survey in Senegal and Tanzania [38] and were again reviewed and validated, to fit the Nigerian context and clinical guidelines in 2013. All health workers were asked to complete all seven cases. This analysis uses results only for one of the hypothetical child cases; the case of a 5 year old girl with pneumonia.

Before the interview began, enumerators explained the interview process, recorded basic health worker information and performed a demonstration of a clinical vignette where one acted as the interviewer and the other as the health worker. The health worker was encouraged to ask any questions of clarification and provide their consent to proceed. For each hypothetical case, the enumerator, acting as the patient, presented him/herself, mentioning basic symptoms and the reason for seeking care. The pneumonia case for example, begins as follows: "*Good morning (afternoon) doctor. I am the mother of this 5 year-old girl. Her name is Sia. She has a cough*." Following the introduction of the hypothetical case, the health worker asked any questions that were relevant for him/her to reach a diagnosis and treatment. The questionnaire is designed for the "patient" enumerator to provide standard answers to the health worker's questions. The health worker can verbally perform a physical examination by asking such questions as "What is the temperature of the patient", for which the standardized response from the interviewer would be "38.5°C". All health workers were asked to give a diagnosis and recommend a treatment for each hypothetical case. The "observer" enumerator recorded all questions asked by the health worker for each hypothetical case. The questionnaire included the complete set of questions necessary to determine a presumptive diagnosis and recommended treatment as outlined in the national standing orders (clinical guidelines). The questionnaire also included, approximately twice as many, commonly asked, non-essential questions that can be relevant or irrelevant to the diagnosis and treatment of the case.

The health worker has been instructed to investigate the case as he/she would normally do and to ask any questions relevant to the patient's history, physical examination, laboratory or other tests and then propose a diagnosis and treatment. The case is designed in such a way that if the health worker asks about the specific symptoms, he/she would find the child to have suffered

from a cough for five days, the cough to be productive with yellowish sputum, having had fever, some chest pain, difficulty breathing but, no difficulty swallowing (Table 8). If the health worker is to examine the child he/she would find she is breathing at 42 breaths per minute, shows no chest in-drawing or wheezing, has a 38.5°C fever and a crepitus of the lungs can be heard. If the health worker asks for laboratory tests, he/she would find a normal blood/count, no malaria parasites and in an x-ray, bilateral patchy opacities/consolidations.

The Nigerian National Standing Orders guide the health worker to suspect a case of pneumonia after finding a respiratory rate of more than 40 breadths per minute, a temperature above 37°C, auscultating to find the chest is not clear, difficulty breathing but, no difficulty swallowing, nor lower chest wall in-drawing. For such cases the Standing Orders recommend the health worker treat the patient with Co-trimoxazole or Amoxicillin antibiotics as well as with paracetamol to reduce the fever. The standing orders also recommend the child be assessed again and hence recommend the health worker ask the parent to bring the child back to the facility in 2 days time (Table 8).

In this analysis we assessed health worker knowledge of consultation process guidelines defining this as the percentage of the six consultation process questions or investigations necessary for defining a diagnosis, as instructed by the National Standing Orders. We assessed the health worker's ability to correctly diagnose the case if they mentioned (when prompted) that the case diagnosis is that of pneumonia. Similarly we assessed the health worker's ability to correctly treat the case according to whether they mentioned each and all three, treatment components outlined in the Standing Orders: (1) Co-trimoxazole or Amoxicillin antibiotics, (2) paracetamol, and (3) ask the parent to bring the child for follow-up in two days time. To explore the possibility that health workers know how to treat a case of pneumonia with other, not

preferred but effective antibiotics, we created a dichotomous variable of the knowledge of any effective antibiotics [145,146], coded as one when the health worker recommended a treatment with Co-trimoxazole, Amoxicillin, Penicillin, Ampicillin, Erythromycin, Clarythromycin or Ceftriaxzone. Using recommendation of any effective antibiotic resulted in the knowledge of full treatment to change for only four health workers Because of this minimal difference we chose to stick to the Standing Orders recommendation of antibiotic use for measuring treatment knowledge. The National Standing Orders were considered as the minimum standard of care to be delivered at primary and secondary level health facilities. Due to limitations of our data, we did not differentiate between treatment timing and doses in medications prescribed by health workers, if the medication was mentioned we considered it as correct, for this analysis.

Table 8: Case presentation, National Standing Orders and Knowledge Score criteria for consultation, diagnosis and treatment of a case of pneumonia in a patient under the age of 5

Vignette Case Presentation	Knowledge score based on National Standing Orders
Pneumonia- 5 year old girl with a cough ***Specific Symptoms if asked:*** Main symptoms: 5 days with cough, productive cough, yellow sputum, chest pain, difficulty breathing, no difficulty swallowing, fever. Physical examination: 42 breadths per minute, no chest in-drawing or wheezing, crepitus of the lungs, 38.5C temperature. Tests: Normal blood count, no malaria parasites, x-ray shows bilateral patchy opacities/consolidations	Adherence to Consultation Process Guidelines (% of 6): 1) Presence of difficulty in breathing 2) Difficulty in swallowing 3) Count respiratory rate 4) Observe breathing for lower chest wall in-drawing 5) Auscultate the chest 6) Take temperature Diagnosis: Pneumonia Full Treatment (all 3: dichotomous variable): 1) Cotrimoxazole 1 tab bd 5/7 OR Amoxicillin 250 mg qds x5 AND 2) Paracetamol 250 mg qds x 5 days 3) Ask parent to bring child in 2 days

Analysis

Facility-level fixed effects logistic regression models were used to compare the knowledge of pneumonia consultation process guidelines, diagnostic accuracy, overall and specific treatment guideline components, of Medical Officers with that of non-physician clinician cadres. Based on existing literature (and variation across cadres in our sample), but restricted by available survey measures, we understood health worker knowledge as a function of individual health

worker and facility-level characteristics. We included dummy variables for 10 different health worker cadres or general groups of cadres using Medical Officers as the reference cadre in our models. Medical Officers are physicians with four or more years of clinical training and are used as our point of comparison as the standard of training for clinical care in a task-shifting strategy. Although included as individual dummy variables, we define non-physician clinicians as CHOs, CHEWs, JCHEWs, Nurse Officers and Nurse Midwives. We also included environmental health officers/assistants, community health assistants, health attendants/auxiliary nurses and dental officers/nurses/technicians, as a way to validate our measures, hypothesizing that these lower level cadres that have not received training in the delivery of primary care ought to perform less well in our measures of knowledge than the higher-level cadres.

Aside from health worker cadre (our independent variable of interest) we included controls for gender, years of experience as a health worker and a variable for the total number of non-essential questions the health worker asked across the five vignette cases. We found a high correlation (78.8%) between the variables of age and years of experience and chose to avoid multicollinearity in our models by including only years of experience, which we deemed to be theoretically more relevant to our knowledge models.

Furthermore, more outgoing and talkative health workers could naturally ask more questions and by chance ask more essential consultation questions as outlined in the clinical guidelines. Therefore, we included, as a proxy, a variable for the number of non-essential questions asked by the health worker across the five vignette cases. This represented the number of questions included in the questionnaire that the health worker asked, which were not essential to the consultation process for the case as outlined by the standing orders; these questions could be relevant or irrelevant altogether. Non-essential questions that were not included in the

questionnaire were recorded as notes, however, we found the length of these to be correlated with the individual enumerator undertaking the interview, and hence did not consider this as a reliable measure.

RESULTS

Sample characteristics

We assessed the knowledge of a total of 5,103 health workers that represent a population of approximately 52,000 health workers who regularly perform outpatient consultations at public primary and secondary health facilities in 12 Nigerian states (Table 2). We found that across the 12 states included in our sample, the vast majority (79.8%) of health workers that regularly provide outpatient consultations in public primary and secondary level facilities are non-physician clinicians, 9.7% are Medical Officers and 10.5% are lower-level cadres who have not been trained to provide this type of care. This weighted proportion of health worker cadres varies widely across states, however. Our results highlight the lack of and maldistribution of Medical Officers who represent 1.4% of the health workforce in the state of Bauchi, but over 25% in Bayelsa, are posted primarily to hospitals (79%) and to urban areas (79%). With some variation across cadres, on average, health workers in these 12 states are nearly 40 years old, have 11.3 years of experience, are primarily female (67.3%), are posted to health centers (53.9%) as opposed to hospitals (19.3%), health clinics (18.9%) or health posts/dispensaries (7.9%), and just over half can be found working in rural areas (52.5%).

Table 9: Health Worker Sample Characteristics by Cadre

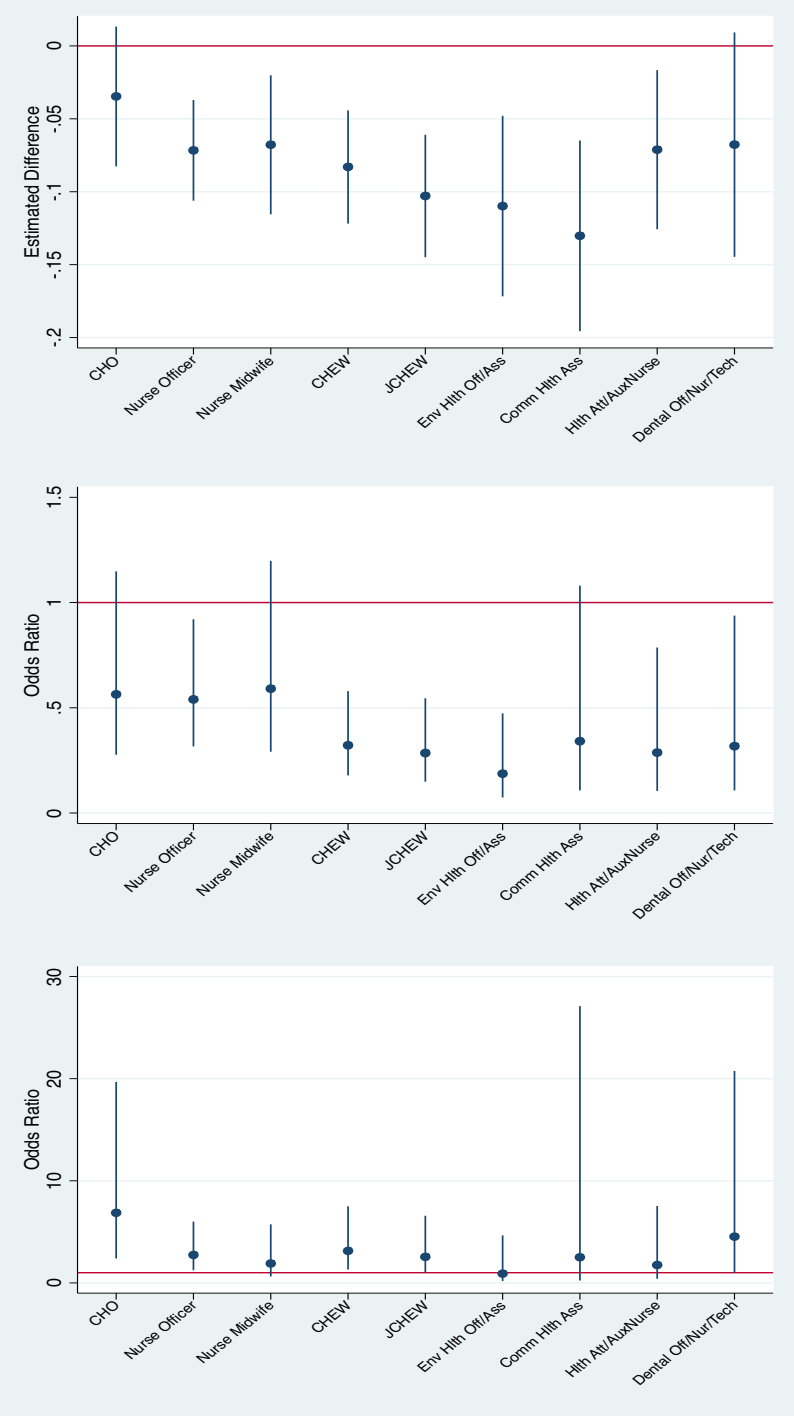
	Medical Officer	CHO	Nurse Officer	Nurse Midwife	CHEW	JCHEW	Env Hlth Off/Ass	Comm Hlth Ass	Hlth Att/AuxNurse	Dental Off/Nur/Tech	Total
N	539	266	872	206	1,951	822	111	96	195	45	5,103
Wtd prop	9.7	5.1	15.4	4.6	37.5	17.2	2.1	1.9	5.7	0.8	100
Age (years) (CI)	39.9 (38.4-41.4)	45.0[a] (43. 8-46.3)	45.5[a] (44.6-46.4)	37.8 (35.7-39.8)	40.3 (39.8-40.8)	35.3[a] (34.5-36.1)	33.7[a] (32.1-35.2)	41.7 (39.6-43.7)	40.9 (37.8-43.9)	34.0[a] (30.8-37.3)	39.9 (38.3-41.4)
Experience (years) (CI)	11.3 (9. 7-13.0)	20.4[a] (18.9-22.0)	19.5[a] (18.3-20.7)	10.9 (7.9-13.8)	15.0[a] (14.4-15.5)	10.2 (9.5-10.9)	7.9[a] (6.8-8.9)	16.3[a] (13.7-18.8)	14.6 (11.6-17.6)	8.1 (5.1-11.0)	11.3 (9.7-13.0)
Female (%)	19.8	60.7	75.8	98.7	71.3	66.3	36.9	78.0	90.7	65.5	67.3
Rural (%)	20.7	50.0	36.9	64.3	57.3	66.2	71.0	52.4	65.2	29.8	52.5
Facility Type											
Hlth Po/Di	0.7	6.1	1.6	3.2	10.4	11.4	17.4	19.4	9.6	5.5	7.9
Hlth Clin	7.4	14.5	13.8	8.7	24.7	26.5	21.6	11.0	4.2	25.5	18.9
Hlth Ctr	13.2	73.5	51.1	70.3	60.0	56.7	59.0	63.9	48.4	39.9	53.9
Hospital	78.8	5.9	33.5	17.8	4.9	5.5	2.9	5.8	37.8	29.2	19.3
(Total)	100	100	100	100	100	100	100	100	100	100	100
State											
Anambra	4.1	2.4	32.0	7.3	41.9	8.4	0.1	1.4	2.3	0.1	100
Bauchi	1.4	3.4	14.2	0.6	39.1	26.8	13.0	0.6	0.8	0.1	100
Bayelsa	25.3	6.0	15.1	11.3	18.3	10.1	0.1	0.1	5.7	8.1	100
Cross River	4.3	14.9	14.5	2.7	50.5	11.7	0.0	0.6	0.6	0.2	100
Ekiti	7.6	3.8	19.2	3.1	48.2	9.0	0.1	3.4	3.1	2.6	100
Imo	14.6	2.6	14.4	10.3	22.8	11.2	2.5	3.0	18.6	0.0	100
Kaduna	16.4	10.1	15.0	2.1	38.3	16.6	0.9	0.5	0.1	0.0	100
Kebbi	6.5	1.9	14.3	9.0	38.2	19.8	6.9	0.6	0.3	2.4	100
Kogi	10.2	4.1	20.3	3.1	42.5	16.3	0.2	1.6	1.1	0.6	100
Niger	4.6	2.7	8.9	1.6	47.9	33.7	0.0	0.1	0.5	0.0	100
Osun	12.6	6.5	16.1	2.3	27.4	10.7	0.0	5.8	17.7	0.9	100
Taraba	4.9	2.1	14.5	3.6	42.5	21.0	2.8	3.9	3.8	0.9	100

Note: Averages and proportions presented are weighted for the inverse probability of selection of each health worker across the different cadres. [a] t-test difference with Medical Officers $p<0.05$

Cadre differences in consultation process outcomes

Overall, Medical Officers show significantly higher knowledge of the consultation process, significantly higher diagnostic accuracy, but significantly lower knowledge of the treatment guidelines than non-physician clinicians. Adjusting for health worker and facility level characteristics, we find that Nurse Officers, Nurse Midwives, CHEWs and JCHEWs, but not CHOs, ask a significantly lower proportion of consultation process questions (as outlined in the National Standing Orders), than do Medical Officers (Figure 5, (a)). Similarly, Nurse Officers, CHEWs and JCHEWs but not CHOs and Nurse Midwives, have significantly lower odds of accurately diagnosing a case of pneumonia than Medical Officers (Figure 5, (b)). However, adjusting for these health worker and facility level characteristics, we find that all non-physician clinicians have higher odds of recommending a full treatment, as outlined in the guidelines for the hypothetical case of pneumonia, compared to Medical Officers: the difference with CHOs, Nurse Officers and CHEWs is statistically significant with odds ratios of 6.9, 2.7 and 3.1, respectively (Figure 5, (c)).

Figure 5: Adjusted differences in the proportion of knowledge of consultation process questions asked, diagnostic accuracy and knowledge of treatment guidelines for pneumonia as compared to Medical Officers



Note: a) Percentage point difference in the proportion of consultation process questions, b) odds ratio of diagnostic accuracy and c) odds ratio of full treatment. Reference lines (zero in model (a) and one in models (b) and (c)), represent no difference with Medical Officers. All estimates are adjusted for health worker gender, experience, number of total non-essential questions asked and facility-level characteristics. Robust standard errors are used to define confidence intervals. See Annex for specific estimates.

Cadre Differences in pneumonia treatment knowledge

Simple weighted means point to low overall knowledge of each component of the pneumonia treatment guidelines across all cadres (Table 10). Only 13% of health workers of primary and secondary health facilities in 12 States in Nigeria, know to recommend the three treatment components (amoxicillin or co-trimoxazole antibiotics, paracetamol and follow-up within two days time, as outlined in the National Standing Orders), to a hypothetical case of pneumonia. A significantly smaller percentage of Medical Officers know to recommend amoxicillin or co-trimoxazole as the antibiotic of choice compared to CHOs, Nurse Officers, CHEWs and JCHEWs. Even when we consider the knowledge of other effective antibiotics (Penicillin, Ampicillin, Erythromycin, Clarythromycin or Ceftriaxzone) in the measure of antibiotic treatment knowledge, a significantly smaller percentage of Medical Officers know to recommend these than do CHOs, Nurse Officers, CHEWs and JCHEWs. Similarly, a significantly smaller percentage of Medical Officers know to recommend paracetamol for the reduction of fever in a hypothetical child with pneumonia than do all non-physician clinician cadres except JCHEWs. Less than 20% of all health workers of public primary and secondary health facilities in our sample states know to recommend a follow-up visit within two days time for a child with pneumonia. The percentage of Medical Officers who recommend follow-up is smaller than the percentage of all non-physician clinician cadres, and significantly smaller than CHOs.

Table 10: Differences across health worker and facility characteristics for the prescription of the recommended antibiotics, any effective antibiotics, paracetamol, follow-up in two days time and a full recommended treatment.

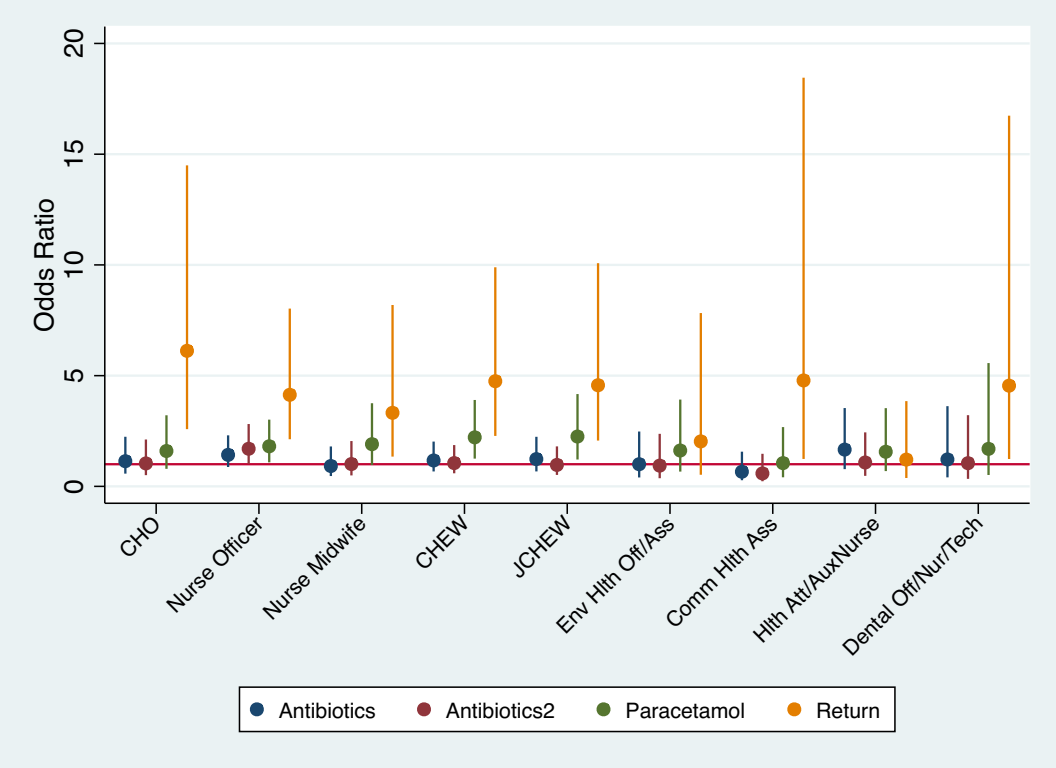
		Amoxicillin or Co-trimoxazole		Any effective antibiotics		Paracetamol		Follow-up in 2 days		Full Recommended Treatment	
	N	%	CI	%	CI	%	CI	%	CI	%	CI
Cadre											
Medical Officer	465	53.2	(38.4-68.0)	57.9	(45.3-70.6)	52.3	(37.8-66.8)	18.4	(10.3-26.6)	14.7	(7.3-22.1)
CHO	247	72.5[a]	(64.6-80.3)	77.1[a]	(70.3-84.0)	64.1[a]	(54.1-74.0)	27.7[a]	(18.7-36.7)	19.4	(10.3-28.6)
Nurse Officer	801	66.6[a]	(61.4-71.9)	74.5[a]	(69.7-79.4)	61.7[a]	(56.7-66.7)	19.4	(14.9-23.8)	14.6	(10.7-18.5)
Nurse Midwife	182	58.2	(45.5-70.8)	67.0	(53.4-80.6)	68.5[a]	(55.1-81.9)	25.6	(10.1-41.1)	12.4	(4.1-20.7)
CHEW	1,831	65.2[a]	(61.4-68.9)	71.2[a]	(67.7-74.6)	61.5[a]	(57.4-65.5)	19.9	(16.9-22.9)	13.2	(10.5-15.9)
JCHEW	791	64.2[a]	(58.8-69.7)	68.6[a]	(63.0-74.2)	59.2	(53.7-64.8)	20.6	(14.9-26.3)	12.6	(8.7-16.6)
Env Hlth Off/Ass	104	58.3	(38.1-78.6)	68.0	(46.7-89.3)	51.0	(32.8-69.2)	7.9 [a]	(2.7-13.2)	5.6 [a]	(1.2-10.1)
Comm Hlth Ass	92	52.3	(38.5-66.0)	60.3	(45.6-75.0)	52.4	(39.5-65.3)	15.7	(5.0-26.3)	3.4 [a]	(-0.9-7.6)
Hlth Att/AuxNurse	192	42.1	(33.2-51.1)	45.1	(35.2-54.9)	56.0	(38.4-73.6)	11.3	(4.2-18.5)	5.2 [a]	(0.8-9.6)
Dental Off/Nur/Tech	41	35.4	(12.8-57.9)	37.3	(14.5-60.0)	52.3	(22.8-81.7)	19.8	(3.3-36.3)	14.8	(1.6-28.0)
All	4,767	62.2	(59.0-65.4)	68.0	(46.7-89.3)	59.9	(56.4-63.5)	19.7	(17.2-22.2)	13.0	(10.9-15.1)

Note: Each value represents the percentage of health workers within each category, who know to prescribe the recommended antibiotics (amoxicillin or co-trimoxazole), any correct antibiotics* (amoxicillin, co-trimoxazole, Penicillin, Ampicillin, Erythromycin, Clarythromycin or Ceftriaxzone), paracetamol, recommended the parent bring the child back for follow-up in two days time or prescribed the three treatment components. All values presented are weighted averages. a: significant difference (t-test, $p<0.05$) compared to Medical Officers.

Regression Models

After controlling for health worker and facility-level characteristics, we find higher but not significant differences between the odds of non-physician clinicians and Medical Officers of knowing to prescribe the recommended antibiotic treatment for pneumonia (even when we include other effective antibiotics), higher odds of knowing to prescribe paracetamol and significantly higher odds of knowing to recommend follow-up within two days time (Figure 6). Medical Officers have the same odds of knowing to prescribe recommended antibiotics, any effective antibiotics and paracetamol than non-physician clinicians. However, Medical Officers are as or less likely to know to recommend follow-up within two days time than lower level cadres who have not received training for the treatment of a case of pneumonia.

Figure 6: Adjusted Odds Ratio for the knowledge of each pneumonia treatment component for all cadres as compared to Medical Officers



Note: Estimates are odds ratios adjusted for health worker experience, gender, number of non-essential questions asked and facility-level characteristics. *Antibiotics* represents the odds of knowing to prescribe amoxicillin or co-trimoxazole, *Antibiotics2* represents the odds of knowing to prescribe any effective antibiotics, *Paracetamol* is the odds or knowing to prescribe paracetamol and *Return* is the odds of knowing to recommend follow-up within two days time. A value of one represents no difference in odds compared to Medical Officers. See Table 11 for specific estimates

We find no significant differences in the odds of knowing to prescribe amoxicillin or co-trimoxazole as the antibiotic of choice when comparing non-physician clinicians to Medical Officers (Table 11). If we look instead at the knowledge of prescribing any effective antibiotics, we continue to find no significant difference in knowledge between non-physician clinicians and Medical Officers except for the case of Nurse Officers who have 1.7 the odds of knowing to recommend effective antibiotics than Medical Officers. Nurse Officers, CHEWs and JCHEWs have 1.8, 2.21 and 2.24 the odds of knowing to recommend paracetamol to a child with pneumonia than are Medical Officers while the odds of CHOs and Nurse Midwives is higher (1.6 and 1.9 respectively) but not significant. CHOs, Nurse Officers, Nurse Midwives, CHEWs and JCHEWs have 6.1, 4.1, 4.3, 4.7 and 4.6 the odds of knowing to recommend the parent bring the child back for a follow-up visit within two days time, than Medical Officers. Overall, while all non-physician clinicians have higher odds of knowing to recommend the three treatment components for a case of pneumonia, CHOs, Nurse Officers and CHEWs have significantly higher (6.9, 2.7 and 3.1) odds than Medical Officers.

We find that neither gender nor years of experience as a health worker significantly increases the odds of knowing to prescribe any treatment component or all treatments, when controlling for cadre, number of non-essential questions and facility-level characteristics. We also find that controlling for other factors, the total number of non-essential questions asked by a health worker during the vignette interview process significantly increases the odds of knowing to prescribe each and all of the treatment components recommended for a case of pneumonia.

Table 11: Facility-level logistic fixed effects models for the odds ratio of knowing to recommend each component for the treatment of pneumonia

VARIABLES	(1) Recommended Antibiotics	(2) Any Effective Antibiotics	(3) Paracetamol	(4) Bring Child Back	(5) All Recommended Treatment
Medical Officer	[ref]	[ref]	[ref]	[ref]	[ref]
CHO	1.135	1.035	1.595	6.120***	6.857***
	(0.394)	(0.378)	(0.569)	(2.692)	(3.690)
Nurse Officer	1.420	1.695**	1.807**	4.132***	2.735**
	(0.351)	(0.438)	(0.471)	(1.400)	(1.097)
Nurse Midwife	0.916	1.006	1.903*	3.318***	1.898
	(0.316)	(0.364)	(0.660)	(1.530)	(1.071)
CHEW	1.167	1.049	2.211***	4.747***	3.134**
	(0.328)	(0.308)	(0.640)	(1.778)	(1.396)
JCHEW	1.229	0.966	2.248**	4.565***	2.549*
	(0.376)	(0.308)	(0.708)	(1.844)	(1.233)
Env Hlth Off/Ass	0.999	0.934	1.617	2.027	0.905
	(0.463)	(0.444)	(0.730)	(1.397)	(0.756)
Comm Hlth Ass	0.658	0.582	1.048	4.782**	2.509
	(0.291)	(0.275)	(0.501)	(3.295)	(3.046)
Hlth Att/AuxNurse	1.659	1.076	1.560	1.207	1.747
	(0.641)	(0.449)	(0.650)	(0.714)	(1.302)
Dental Off/Nur/Tech	1.213	1.045	1.691	4.546**	4.528*
	(0.677)	(0.599)	(1.028)	(3.023)	(3.517)
Female	0.811	0.813	1.000	0.889	0.966
	(0.113)	(0.121)	(0.138)	(0.154)	(0.207)
Years of Experience	0.993	0.995	1.004	0.998	0.995
	(0.00513)	(0.00559)	(0.00536)	(0.00702)	(0.00869)
Total non-ess Ques	1.024***	1.026***	1.031***	1.038***	1.049***
	(0.00360)	(0.00376)	(0.00385)	(0.00438)	(0.00549)
Hausman test with OLS	(chi2=168.82. p=0.0000)	(chi2=82.49. p=0.0000)	(chi2=15.28. p=0.2264)	(chi2=54.42. p=0.0000)	(chi2=79.45. p=0.0000)
Hausman test with RE	(chi2=45.49. p=0.0000)	(chi2=35.67. p=0.0000)	(chi2=23.47. p=0.0240)	(chi2=27.75. p=0.0000)	(chi2=15.59. p=0.2107)
Rho[i]	0.4635	0.4747	0.4618	0.4790	0.4840
Observations	2,238	2,046	2,274	1,527	1,128
Number of facilities	644	581	647	414	295

Note: The table presents estimates of facility-level logistic fixed effects models for the Odds Ratio of knowing to prescribe each pneumonia treatment component and all treatment components as compared to Medical Officers. Facilities not included in the models had all positive or all negative outcome values. Rho is calculated using equally specified linear probability models. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

DISCUSSION

As a primary cause of under-5 mortality in Nigeria, the ability of health workers to diagnose and treat a child with pneumonia, is of utmost importance to the fight against the dire consequences of this disease. Our overall findings show that in public primary and secondary facilities that

provide outpatient consultations, across 12 Nigerian states, less than half of all health workers know to give the correct diagnosis of pneumonia and, just over 1 in 10 knows to recommend the three treatment components outlined in the National Standing Orders. With the exception of Medical Officers, cadres with a greater number of years of training generally show a higher knowledge of the pneumonia treatment guidelines than lower-level cadres. We find that although Medical Officers display a significantly higher knowledge of the consultation process guidelines and are significantly better able to diagnose a case of pneumonia than all other cadres, they are significantly less knowledgeable of the three treatment components included in the guidelines when compared to non-physician clinicians.

In a detailed analysis comparing the knowledge of each treatment component between Medical Officers and non-physician clinicians, we find no difference between these cadres related to the recommendation of antibiotics outlined in the clinical guidelines even when we adjust our measure to include of any other effective antibiotics. We find that Nurse Officers, CHEWs and JCHEWs are more likely to know to recommend paracetamol for a child with pneumonia than Medical Officers while no difference in knowledge of this component could be found when comparing with CHOs and Nurse Midwives. We consistently find, however, that non-physician clinicians have significantly higher odds of recommending the parent bring a child for a follow-up visit within two days, than Medical Officers.

Prescribing the correct treatment antibiotics is likely the largest determinant (among the three treatment components) of a positive health outcome in a child with pneumonia [147,148]. We find that less than 70% of health workers in public primary and secondary facilities across 12 Nigerian states know to recommend treatment with an effective antibiotic to a child with pneumonia and there are no significant differences in this knowledge, between Medical Officers

and non-physician clinicians or even lower-level cadres. Finding that non-physician clinicians and lower-level untrained health workers have equal odds of knowing to recommend co-trimoxazole or amoxicillin for the treatment of pneumonia is good news for a task-shifting policy but perhaps, not very good news for Medical Officers. Our results confirm that the low, recorded knowledge for Medical Officers is not due to the restrictiveness of our measure; we find no difference between cadres even when we include the possibility of a recommendation of other effective antibiotics. Our results suggest that in considering only the provision of antibiotics, non-physician clinicians have the potential to provide equal care to patients with pneumonia as compared to Medical Officers and could be tasked with this role. The low overall knowledge of this treatment component raises an important flag for efforts to reduce pneumonia mortality in Nigeria.

Medical Officers are, overall, significantly less knowledgeable of the recommendation of paracetamol and follow-up within two days time than non-physician clinicians, as necessary components for the treatment of a child with pneumonia. This result is surprisingly different from our previous findings where Medical Officers consistently display higher knowledge across different vignette illnesses and knowledge measures (Paper1). With the objective of reducing a patient's fever and discomfort, health workers are expected to recommend paracetamol as supportive treatment for a case of childhood pneumonia. We find that less than 60% of health workers in public primary and secondary health facilities in 12 Nigerian states, know to recommend this as one of the treatments for a child presenting with pneumonia symptoms. We find that, controlling for other factors, CHOs and Nurse Midwives have equal odds of recommending this treatment while Nurse Officers, CHEWs and CHOs have higher odds when compared to Medical Officers. Similarly, health workers are expected to reassess a child with pneumonia within two days time, to ensure the adequacy of the diagnosis and treatment

[146]. Our results point to very low overall knowledge of this treatment component across all cadres and a significantly lower knowledge of Medical Officers when compared to non-physician clinicians.

The low recommendation of these simple treatment measures by Medical Officers is surprising and cannot be explained by our available data. We hypothesize that this finding can be due to either of two possibilities; (1) Medical Officers are simply less likely to know to recommend paracetamol, or (2) for reasons unknown, Medical Officers are less likely to report the full details of their treatment knowledge because they may think paracetemol is trivial to mention and so confine themselves to mentioning only the antibiotic treatment. We believe the last possibility is unlikely given our observation of the consistently higher displayed knowledge of Medical Officers as compared to other cadres for the consultation process, diagnostic accuracy and even across a number of other illnesses (refer to paper 1) even after controlling for facility characteristics that could include their location, type of facility or caseload among other factors.

Although studies comparing the performance of non-physician clinicians to that of physicians tend to point to no differences between these cadres [30,31,35,145], this is not the first study to find that non-physician clinicians can perform better than physicians or higher-level cadres when providing medical services. Studies have found that non-physician clinicians can reduce mortality, CD4 counts and increase retention of patients with HIV [100,106], can reduce the rate of infections and complications when performing voluntary male circumcisions [149], can better perform patient follow-up after surgery [71] and can achieve greater patient satisfaction [84,87] when compared to physicians.

Across all our models we find that neither gender nor years of experience significantly affect a

health worker's knowledge of the pneumonia treatment guidelines, but, we find that the greater the number of non-essential questions asked by a health worker in the vignettes interview, the greater their pneumonia treatment knowledge. This result provides further support to our previous findings, where the number of non-essential questions asked by a health worker was significantly and positively correlated with a health worker's general knowledge of consultation guidelines for primary care, their overall diagnostic accuracy and their overall knowledge of treatment guidelines (Paper 1). With these analyses we find that this variable is consistent in its correlation with health worker knowledge even when we consider the health worker's knowledge of specific treatment components. The importance of this factor across each of our models suggests that this intrinsic ability could be as, or more important than the health worker's formal training (reflected by their cadre) to the knowledge necessary for the provision of care to pneumonia patients.

CONCLUSION

Low overall public primary and secondary level health worker knowledge of the recommended treatment of childhood pneumonia ought to be of primary concern to policy-makers and other stakeholders trying to reduce child mortality in Nigeria. We find that although Medical Officers have significantly greater knowledge of the consultation process guidelines and are better able to identify a case of pneumonia, they are equal or less likely to know to prescribe the full treatment to a child with this illness than are non-physician clinicians. Our findings suggest that non-physician clinicians compare favorably with Medical Officers/ fully trained doctors in their knowledge to prescribe recommended or effective antibiotics, equal or lower knowledge to recommend paracetamol and lower knowledge of the recommendation of follow-up, as do Medical Officers, when treating a childhood case of pneumonia. Non-physician clinicians have the potential to take on the task of treating patients with pneumonia, however, strategies

should focus on increasing overall knowledge for all cadres, including Medical Officers.

Chapter 5: (Paper 3) As good as physicians, but not good enough? Non-Physician clinician screening for type II Diabetes in Nigeria

ABSTRACT

Background: The prevalence of diabetes across sub-Saharan Africa is rapidly increasing: by 2030 Nigeria is estimated to have over 5.3 million adults living with this illness. High mortality and morbidity rates from diabetes have been attributed to low health worker awareness and knowledge. With a low availability and maldistribution of physicians in Nigeria, primary care is most often delivered by non-physician clinicians, who, among other things, have been charged with identifying diabetes patients.

Methods: This study compares the knowledge of Medical Officers and non-physician clinicians who regularly deliver outpatient consultations in public primary care facilities across 12 Nigerian states. Non-physician clinicians were defined as Community Health Officers (CHOs), Nurse Officers, Nurse Midwives, Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs). We assessed 4,138 health workers using clinical vignettes for a case of a man presenting with symptoms of type II Diabetes. Facility-level OLS and logistic fixed effects models were used to compare health worker knowledge of the diabetes consultation process guidelines and their diagnostic accuracy.

Results: Within a context of very low overall knowledge, we find that Medical Officers are more likely to know the clinical guidelines for the screening of a patient with type II Diabetes when compared to CHOs, CHEWs and JCHEWs but not Nurse Officers or Nurse Midwives. Although Medical Officers have greater knowledge of the guidelines, they are not more accurate in their identification of a hypothetical type II Diabetes case than are all non-physician clinician cadres

except for JCHEWs. Low overall knowledge, asking more non-essential questions and facility effects underlie the small or non-existent differences between these cadres.

Conclusion: Our results suggest that all else being equal, non-physician clinicians are equally as likely to know to identify a case of type II Diabetes as Medical Officers and could hence, take on this role.

INTRODUCTION

The prevalence of diabetes across Sub Saharan Africa is rapidly rising. With an average increase of 125,000 cases each year, Nigeria is estimated to have over 5.3 million adults living with diabetes by the year 2030 [44]. Of these cases, approximately 90-95% will be cases of type II diabetes [150]. Unless significant efforts are made, a large proportion of all diabetes cases will continue to be undiagnosed: in 2013, the regional estimated prevalence of undiagnosed diabetes was 50.7% with a much higher prevalence (75.1%) among low-income individuals [150]. Low diagnosis and high mortality rates from diabetes have been attributed, in part, to the low availability of diagnostic tests and equipment in facilities as well as to low health worker awareness and knowledge for the diagnosis and management of this illness [151,152]. A number of studies, have pointed to the importance and feasibility of early detection strategies to improve management and prevent diabetes-related complications and death [153–159].

As a response to a chronic shortage and an urban-rural maldistribution of physicians, since the 1970's, Nigeria has implicitly implemented a wide reaching task-shifting strategy where non-physician clinicians have been trained to provide care in, and manage primary health facilities [37]. Community Health Officers (CHOs), Community Health Extension Workers (CHEWs) and Junior Community Health Extension Workers (JCHEWs) are trained for four, two and one year, respectively, to deliver primary health care services, including the screening of persons with diabetes [48]. At the health facility, with the support of available nurses and lower-level health worker cadres, CHOs, CHEWs and JCHEWs give outpatient consultations, write prescriptions and perform basic treatments as guided by 'National Standing Orders' [61]. These clinical guidelines are a simple and accessible guide for non-physician clinicians for the identification and referral of patients with type II Diabetes. In August of 2014, the Nigerian Federal Government approved a task-shifting and task-sharing policy that has made official and further

expanded the essential role of CHOs, CHEWs, JCHEWs and nurses in the delivery of primary care, specifically mentioning their role in the management of patients with non-communicable diseases [36]. This new policy is relying on the assumption that non-physician clinicians have the knowledge necessary for the provision of these services.

Across the developing world, few studies have assessed the ability of health workers to identify and treat diabetes patients [89,155,160–167]. We are aware of only one study that has compared the ability of non-physician clinicians to diagnose or screen these patients with that of higher level cadres, finding no differences between cadres [89]. With limited evidence, the calls for studies of this nature are ubiquitous [150–152,156–158,168,169].

Findings from the assessment of health workers' knowledge of diabetes in Nigeria suggest low overall knowledge and ability to manage diabetes cases and their complications as well as lower knowledge among mid-level cadres than senior ones [163,165,167]. Although existing studies in Nigeria represent, primarily, physicians working in secondary and tertiary level facilities, the low levels of knowledge reported by these studies are a possible threat to efforts necessary to curb the rising burden of diabetes and other non-communicable diseases. Low levels of knowledge among higher-level cadres are also likely to signify even lower level of knowledge among non-physician clinician cadres.

With this study we sought to compare the knowledge of consultation process clinical guidelines, and the diagnostic accuracy, for a case of Type II Diabetes, between Medical Officers and non-physician clinicians who regularly deliver primary care in Nigeria. Given the differential expectations for the management of a case of Type II diabetes by Medical Officers and non-physician clinicians, we did not compare the treatment knowledge of this illness across these

cadres. We defined non-physician clinicians as CHOs, Nurse Officers, Nurse Midwives, CHEWs and JCHEWs for this analysis.

METHODS

Sampling

For this study, we used the World Bank's Service Delivery Indicators cross-sectional survey data collected from public sector, primary care facilities in twelve Nigerian states between July 2013 and January 2014. Facilities were sampled from the Federal Government list of public health facilities in Nigeria; facilities were stratified by state and urban/rural status. A total number of 75-100 facilities were then, randomly selected to represent each strata for a total of 150-200 from each state. In each facility, from a health worker roster, those who reported providing outpatient consultations more than once per week were selected for the health worker knowledge interview. In facilities with less than 10 eligible health workers, all health workers present in the facility on the day of the survey were interviewed. In facilities with more than 10 eligible health workers, 10 health workers were randomly selected. From a total of 4,154 that were selected, 16 (less than 1%) refused to participate. A total of 4,138 health workers from 2,113 primary care facilities across 12 states are included in the study.

This sample of health workers included in this study is representative of all public primary care health workers who regularly provide outpatient consultations in the 12 Nigerian states. We calculated and used inverse probability weights for each facility and individual health worker. To calculate the probability of selection of each health worker we estimated (1) the probability of selection for each facility within each strata in the sampling frame, (2) the probability of selection of each health worker using the roster of health workers who reported regularly providing outpatient consultations in each facility and finally (3) we multiplied the probability

of selection of the facility with the probability of selection of the health worker. Probabilities of selection were calculated to account for facility and health worker replacements where necessary.

Assessing Health Worker Knowledge

Health worker knowledge was assessed using clinical vignettes for seven standardized cases, where one enumerator acted as a patient presenting with a basic set of symptoms, and a second, recorded health worker questions, diagnoses, laboratory and treatment recommendations in a standardized questionnaire [89,123,131,132]. The clinical vignettes used in this study were originally developed by a team of World Bank experts for the pilot implementation of the Service Delivery Indicator survey in Senegal and Tanzania[38] and were again reviewed and validated, to fit the Nigerian context and clinical guidelines in 2013. To ensure their acceptability, the vignettes were reviewed by officials from the Nigerian Federal Ministry of health, were then piloted in two rural facilities near Abuja and subsequently adjusted for comments and mistakes.

Before the interview began, enumerators explained the interview process, recorded basic health worker information and performed a demonstration of a clinical vignette where one acted as the interviewer and the other as the health worker. The health worker was encouraged to ask any questions of clarification and provide their consent to proceed. For each hypothetical case, the enumerator, acting as the patient, presented him/herself, mentioning basic symptoms and the reason for seeking care. The diabetes case for example, begins as follows: *"My name is Jack I am worried that something is wrong with me. I feel weak and without energy even though I feel hungry often and eat frequently. I am 48 years old and work as a clerk."* Following the introduction of the hypothetical case, the health worker asked any questions that are relevant

for him/her to reach a diagnosis and treatment. The questionnaire is designed for the "patient" enumerator to provide standard answers to the health worker's questions. All health workers were asked to give a diagnosis and recommend a treatment for each hypothetical case. The "observer" enumerator recorded all questions asked by the health worker for each hypothetical case. The questionnaire included the complete set of questions necessary to determine a presumptive diagnosis and recommended treatment as outlined in the national standing orders (clinical guidelines). The questionnaire also included, approximately twice as many, commonly asked, non-essential questions that can be relevant or irrelevant to the diagnosis and treatment of the case.

The health worker was instructed to investigate the case as he/she would normally do and to ask any questions relevant to the patient's history, physical examination, laboratory or other tests and then propose a diagnosis and treatment. The case is designed in such a way that if the health worker asks about the specific symptoms, he/she would find the patient feels he has to urinate often, he has become increasingly thirsty over the past months, has a normal body weight but a urinalysis shows the presence of ketones and glucose (Table 12). The Nigerian National Standing Orders guide the health worker to suspect this case as a case of Type II Diabetes and recommend the health worker refer the patient to a higher level-facility for treatment. Unlike non-physician clinicians, Medical Officers are expected to prescribe medications for the treatment of the illness regardless of the location of their post.

Table 12: Diabetes vignette case presentation and National Standing Orders case definition

Vignette Case Presentation	Knowledge Score based on National Standing Orders
Diabetes Type II - 48 year old man feeling weak, without energy and is often hungry Specific Symptoms if asked: *History* Eats irregularly but has recently started eating more. Has become increasingly thirsty over the past months. Feels he has to urinate often. Previous health check: three months ago, HIV-negative but blood sugar and blood pressure somewhat high. Family members were never checked for diabetes. Sometimes feels very dizzy. *Physical Examination* Normal weight, height and blood pressure. *Laboratory Tests* Fasting Blood Glucose: 230 mg/dl Blood Slide for malaria: negative Glycated Hemoglobin A1C: 9 Random Blood Glucose: 300mg/dl Urinalysis: Glucose +, Ketones +	Adherence to Consultation Process Guidelines (% of 4): (1) Urinary Output: Passing a lot of urine, getting up more than 4 times at night to pass large quantities of urine but without pain. (2) Thirst: feel very thirsty and drinks a lot of water/fluid. (3) Weight: loss of weight. (4) Urinalysis: examine urine for increased sugar and blood. **Diagnosis:** Severe condition, suspect Diabetes **Treatment (not in analysis):** Refer to hospital (if Medical Officer: Oral Hypoglycemic or insulin when hypoglycemic are not effective)

Analysis

For this analysis we defined two outcomes of interest: (1) knowledge of the consultation process guidelines and (2) diagnostic accuracy. We defined health worker knowledge of consultation process guidelines as the percentage of the 4 consultation process questions or investigations necessary for defining a diagnosis, as instructed by the National Standing Orders: (1) urinary output, (2) thirst, (3) weight and (4) performing a urinalysis (test). We assessed the health worker's ability to correctly diagnose the case if they mentioned (when prompted) that the case diagnosis is that of diabetes. The National Standing Orders were considered as the minimum standard of care to be delivered at primary level health facilities.

We used facility-level fixed effects OLS models to assess differences of the knowledge of consultation process guidelines between health worker cadres and facility-level fixed effects

logistic regression models to assess differences in diagnostic accuracy between these cadres. For both outcomes we first modeled the simple effects of cadre on the outcome with an OLS or logistic regression model, in a second model we included facility characteristics into the previous models, in a third model we used facility-level fixed effects to control for facility characteristics and in a final model (not presented) we used a facility-level random effects model specified equally to the previous model. For the first two OLS or logistic regression models we used facility-level clustered robust standard errors to adjust for our sampling strategy and across all models, we used robust standard errors to adjust for heteroskedasticity. To assess the possibility of a correlation between the explanatory variables of interest in our models and the facility characteristics included as fixed effects, we used Hausman tests to compare the estimates of the random effects and the OLS models with those of the fixed effects model.

RESULTS

Sample characteristics

We assessed the knowledge of a total of 4,138 health workers that represent a population of approximately 42,000 health workers who regularly perform outpatient consultations at public primary health facilities in 12 Nigerian states (Table 2). We found that across the 12 states included in our sample, the vast majority (87.6%) of health workers that provide public primary care are non-physician clinicians, 2.6% are Medical Officers and 9.9% are lower-level cadres who have not been trained to provide this type of care. This weighted proportion of health worker cadres varies widely across states, however. Our results highlight the maldistribution of Medical Officers across states, they represent 0.2% of the public primary health workforce in states like Bauchi and Taraba while representing over 25% in Bayelsa. The proportion of non-physician clinicians also varies between 69% in Bayelsa and 98% in the state of Niger. With some variation across cadres, on average, health workers in these 12 states are

just over 40 years old, have 13.6 years of experience, are primarily female (71.6%), are posted to health centers (66.8%) as opposed to health clinics (23.4%) or health posts/dispensaries (9.8%) and just over half can be found working in rural areas (57.2%).

Table 13: Health Worker Sample Characteristics by cadre

	Medical Officer	CHO	Nurse Officer	Nurse Midwife	CHEW	JCHEW	Env Hlth Off/Ass	Comm Hlth Ass	Hlth Att/AuxNurse	Dental Off/Nur/Tech	Total
N	115	256	497	169	1,891	802	110	93	168	37	4,138
Wtd prop	2.6	5.9	12.7	4.7	44.2	20.1	2.6	2.2	4.4	0.7	100
Age (years) (CI)	40.5 *(36.3-44.7)*	45.0 [a] *(43.7-46.3)*	45.2 [a] *(44.1-46.2)*	36.8 *(34.7-38.9)*	40.4 *(39.9-40.8)*	35.7 [a] *(34.9-36.4)*	33.6 [a] *(32.1-35.2)*	41.1 *(39.3-42.9)*	39.1 *(37.6-40.7)*	34.9 *(31.3-38.6)*	40.5 *(36.3-44.7)*
Experience (years) (CI)	13.6 *(9.6-17.6)*	20.7 [a] *(19.0-22.3)*	19.1 [a] *(17.8-20.4)*	9.2 *(6.4-11.9)*	14.9 *(14.4-15.5)*	10.5 *(9.8-11.2)*	7.9 [a] *(6.8-8.9)*	15.4 *(13.3-17.5)*	12.3 *(10.8-13.8)*	9.9 *(6.4-13.4)*	13.6 *(9.5-17.7)*
Female (%)	20.7	62.3	86.4	99.8	71.2	65.4	37.6	81.4	89.1	70.9	71.6
Rural (%)	13.5	51.0	40.9	72.4	57.9	69.1	70.4	50.8	58.4	41.5	57.2
Facility Type											
Hlth Po/Di	3.0	6.5	2.4	3.9	10.9	12.0	17.8	20.6	15.4	7.7	9.8
Hlth Clin	35.0	15.4	20.7	10.6	26.0	28.0	22.1	11.6	6.7	36.0	23.4
Hlth Ctr	62.0	78.1	76.8	85.5	63.1	60.0	60.1	67.8	77.9	56.3	66.8
(total)	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
State											
Anambra	1.2	2.7	26.7	8.4	47.7	9.5	0.1	1.0	2.6	0.1	100
Bauchi	0.2	3.7	7.5	0.7	42.7	29.3	14.4	0.7	0.8	0.0	100
Bayelsa	25.9	9.6	8.7	9.6	28.4	12.4	0.2	0.2	0.3	4.8	100
Cross River	1.4	15.3	12.6	2.9	53.4	12.9	0.0	0.7	0.6	0.2	100
Ekiti	2.8	4.1	17.9	3.3	52.2	9.8	0.1	3.7	3.4	2.8	100
Imo	1.3	3.3	18.0	13.6	30.4	14.4	3.4	4.1	11.5	0.0	100
Kaduna	4.7	11.6	14.0	2.6	46.8	18.6	1.2	0.6	0.0	0.0	100
Kebbi	0.3	2.6	3.1	6.4	48.3	26.1	9.4	0.8	0.4	2.7	100
Kogi	0.8	7.0	12.4	0.0	53.6	21.1	0.4	3.0	1.0	0.8	100
Niger	1.5	2.4	4.8	1.8	51.7	37.2	0.0	0.1	0.6	0.0	100
Osun	4.0	7.5	17.2	2.6	31.8	11.8	0.0	6.7	17.4	1.0	100
Taraba	0.2	2.4	11.1	3.8	47.3	24.1	2.6	3.2	4.3	1.1	100

Note: Averages and proportions presented are weighted for the inverse probability of selection of each health worker across the different cadres. [a] t-test difference with Medical Officers $p<0.05$

Cadre Differences in outcome measures

Simple weighted mean comparisons of consultation process clinical guidelines and diagnostic accuracy show low overall knowledge as well as significant differences between Medical Officers and non-physician clinicians. Medical Officers ask twice as many consultation questions recommended by the clinical guidelines and twice as many Medical Officers accurately diagnose the hypothetical case as Type II diabetes, when compared to non-physician clinicians (Table 6). Medical Officers on average, know to ask 62.2% of the physical examination and history taking questions recommended for a consultation by the clinical guidelines, significantly more than CHOs (26.7%), Nurse Officers (36.0%), Nurse Midwives (30.7%), CHEWs (19.3%) and JCHEWs (14.6%). Similarly, 59.9% of Medical Officers can accurately identify and diagnose the hypothetical Type II Diabetes case, significantly more than CHOs (30.9%), CHEWs (24.1%) and JCHEWs (18.4%) but not Nurse Officers (30.9%), Nurse Midwives (52.1%). Across the three measures, lower level cadres without primary care consultation training present lower scores than non-physician clinician cadres.

Table 14: Consultation Knowledge Outcomes by Case and Cadre

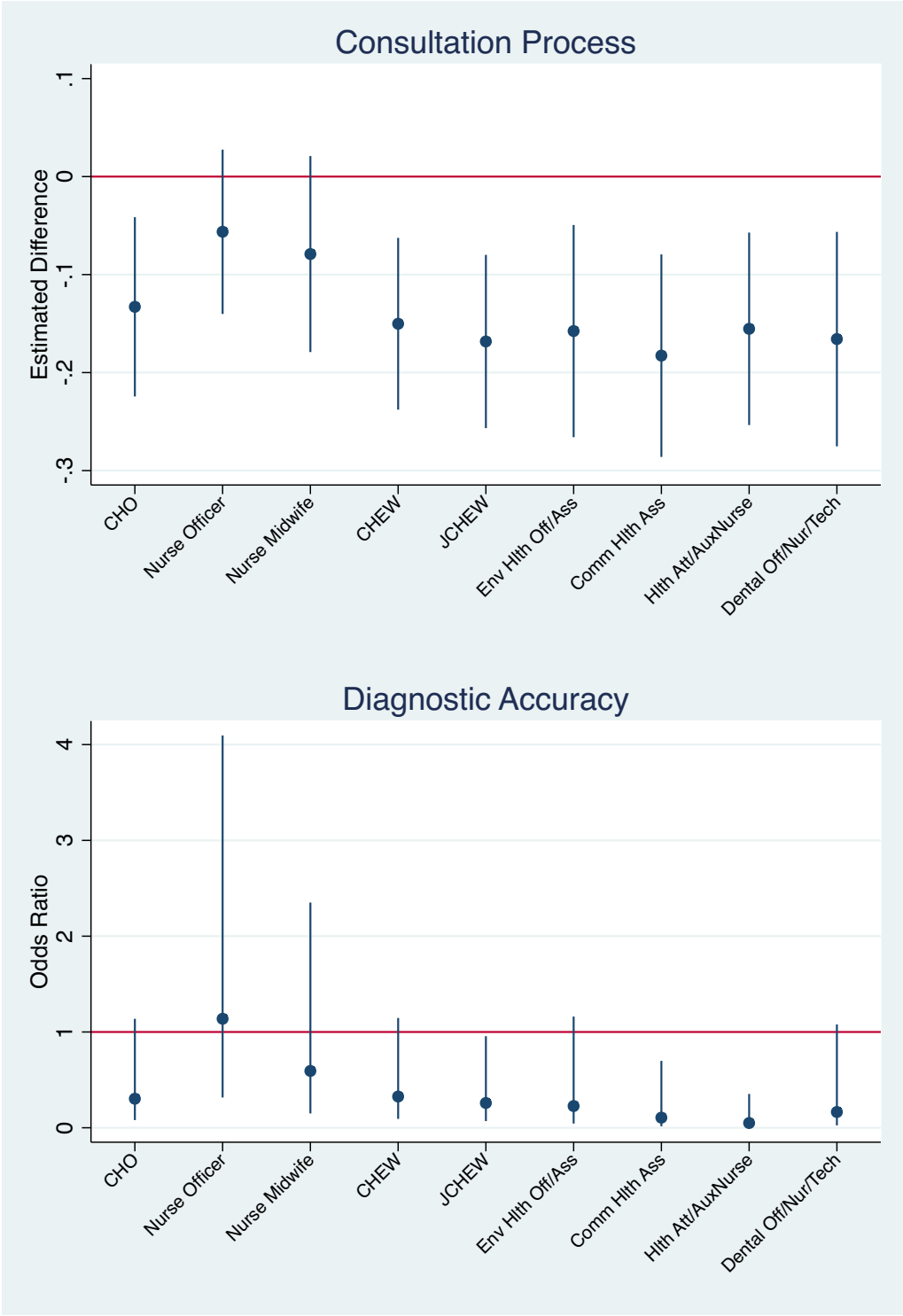
	N	Consultation Process[1]		Diagnosis[2]	
	N	***mean***	***CI***	***%***	***CI***
Cadre					
Medical Officer	107	62.2	(50.8-73.7)	59.9	(44.2-75.5)
CHO	256	26.7[a]	(21.8-31.5)	30.9[a]	(22.0-39.8)
Nurse Officer	494	36.0[a]	(31.8-40.1)	52.1	(45.7-58.5)
Nurse Midwife	168	30.7[a]	(23.4-38.1)	49.3	(35.4-63.2)
CHEW	1,889	19.3[a]	(17.8-20.8)	24.1[a]	(21.2-27.0)
JCHEW	799	14.6[a]	(12.7-16.6)	18.4[a]	(14.2-22.7)
Env Hlth Off/Ass	110	13.6[a]	(8.3-18.8)	21.3[a]	(10.1-32.6)
Comm Hlth Ass	93	11.4[a]	(6.4-16.3)	9.2[a]	(2.6-15.8)
Hlth Att/AuxNurse	167	8.2[a]	(5.1-11.3)	5.8[a]	(1.6-10.0)
Dental Off/Nur/Tech	37	18.9[a]	(6.1-31.6)	26.2[a]	(2.2-50.3)
All	4,120	21.7	(20.5-22.9)	27.8	(25.7-29.9)

Note: Means and percentages presented here are weighted for the inverse probability of selection of each health worker. [1:]The mean for consultation process is calculated as the percentage of four history taking and physical examination questions asked, across each type of health worker. [2:] For each cadre, the % correct diagnosis is calculated as the percentage of health workers in each cadre who know to identify the case as Type II Diabetes. [a:] t-test difference of outcome mean compared to Medical Officers $p<0.05$

Regression Models

Controlling for health worker and facility-level characteristics we find that CHOs, CHEWs and JCHEWs but not Nurse Officers nor Nurse Midwives have significantly lower knowledge of the type II Diabetes consultation process guidelines than Medical Officers. However, we find no difference in diagnostic accuracy between all cadres of non-physician clinicians, except for JCHEWs, when compared to Medical Officers. Lower level cadres generally appear less knowledgeable of the consultation process and diagnostic accuracy than non-physician clinicians and Medical Officers.

Figure 7: Adjusted differences in the knowledge of consultation process guidelines and diagnostic accuracy between Medical Officers and other cadres.



Note: The first graph depicts estimated percentage point differences in the knowledge of the type II diabetes consultation process guidelines while the second depicts the odds ratio of the knowledge of the correct type II diabetes diagnosis. Estimates are adjusted for gender, experience, number of non-essential questions asked and facility level characteristics. The y-value of 0 in the first graph and the y-value of 1 in the second graph represent no difference with Medical Officers. See Table 15, below, for corresponding values.

Knowledge of consultation process clinical guidelines

After controlling for individual health worker and facility-level characteristics, we find that Medical Officers show slightly, yet statistically significantly, more knowledge of the consultation process guidelines for the screening of type II Diabetes than CHOs, CHEWs and JCHEWs but not Nurse Officers or Midwives (Table 15). We find that CHOs, CHEWs and JCHEWs ask an average of 13.3, 15.0 and 16.8 percentage point less recommended consultation questions than Medical Officers, respectively (model 3). We find that the inclusion of health worker characteristic control variables, specifically the inclusion of the number of non-essential questions asked, greatly reduces the difference in consultation knowledge between Medical Officers and non-physician clinicians (model 1 compared to model 2). Controlling for facility-level characteristics in the fixed-effects model, further reduces the estimated difference between Medical Officers and non-physician clinician cadres (model 2 compared to model 3) suggesting that facility-level characteristics have an important effect on health worker knowledge. A equally specified random effects model shows similar results (not shown) to our OLS model (2), where the differences in knowledge between Medical officers and each non-physician clinician cadre are statistically significant. A Hausman test comparing the fixed and random effects models (chi2=13.60, p=0.3272) suggests that we cannot reject the possibility that facility level characteristics are in fact correlated with health worker characteristics included in our model. From our fixed-effects model we find that facility level effects account for 48.4% of the variation in the model, further suggesting that the facility to which a health worker is assigned, has an important effect on their knowledge of the consultation process guidelines for primary care. We find no difference in consultation process knowledge due to gender or years of experience when controlling for health worker and facility-level characteristics.

Diagnostic accuracy

We find no statistical difference in the diagnostic accuracy of CHOs, Nurse Officers, Nurse Midwives and CHEWs compared to Medical Officers, after controlling for health worker and facility-level characteristics (model 6). The diagnostic accuracy of JCHEWs is significantly lower than that of Medical Officers, however: the odds that JCHEWs give a correct diagnosis for a hypothetical case of type II Diabetes is approximately one fourth (0.258) that of Medical Officers. Including health worker characteristic controls, specifically the number of non-essential questions asked, reduces the estimated difference in odds in the diagnostic accuracy when comparing Medical Officers to all cadres of non-physician clinicians (model 4 compared to model 5). The inclusion of facility-level characteristic controls in the fixed-effect model again points to the importance of facilities in health worker diagnostic accuracy for a case of type II diabetes (model 5 compared to model 6). A Hausman test comparing equally specified, fixed effects and random effects models (not shown) suggests (chi2=13.80, p=0.3137), again, that we cannot reject the possibility that facility level characteristics are in fact correlated with health worker characteristics included in our model. From our random-effects model we find that facility level effects account for 40.6% of the variation in the model, suggesting that the facility to which a health worker is assigned, has an important effect on their diagnostic accuracy for type II diabetes. As in the models for the knowledge of consultation process guidelines, we find that diagnostic accuracy increases with the total number of non-essential questions asked by a health worker, even after controlling for health worker and facility-level characteristics.

Table 15: Regression Models for the difference in knowledge of consultation process guidelines and diagnostic accuracy between Medical Officers and other health worked cadres

	Consultation Process (OLS Models)			*Odds Ratios of Diagnostic Accuracy (Logistic Models)*		
VARIABLES	(1) Cadre	(2) Health Worker Characteristic	(3) Fixed Effects-Facility Characteristic	(4) Cadre	(5) Health Worker Characteristic	(6) Fixed Effects-Facility Characteristic
Medical Officer	[ref]	[ref]	[ref]	[ref]	[ref]	[ref]
CHO	-0.355***	-0.174***	-0.133***	0.299**	0.596	0.302*
	(0.0561)	(0.0476)	(0.0466)	(0.144)	(0.255)	(0.204)
Nurse Officer	-0.263***	-0.0839	-0.0563	0.729	1.540	1.137
	(0.0620)	(0.0534)	(0.0428)	(0.297)	(0.569)	(0.743)
Nurse Midwife	-0.315***	-0.129**	-0.0790	0.652	1.223	0.593
	(0.0667)	(0.0546)	(0.0510)	(0.282)	(0.459)	(0.417)
CHEW	-0.429***	-0.210***	-0.150***	0.213***	0.465**	0.326*
	(0.0572)	(0.0491)	(0.0447)	(0.0800)	(0.158)	(0.209)
JCHEW	-0.476***	-0.243***	-0.168***	0.151***	0.350***	0.258**
	(0.0583)	(0.0509)	(0.0451)	(0.0599)	(0.130)	(0.172)
Env Hlth Off/Ass	-0.486***	-0.237***	-0.158***	0.181***	0.503	0.226*
	(0.0667)	(0.0556)	(0.0552)	(0.0826)	(0.234)	(0.189)
Comm Hlth Ass	-0.509***	-0.228***	-0.183***	0.0680***	0.190***	0.106**
	(0.0652)	(0.0533)	(0.0527)	(0.0399)	(0.115)	(0.102)
Hlth Att/AuxNurse	-0.540***	-0.220***	-0.155***	0.0411***	0.143***	0.0490***
	(0.0595)	(0.0525)	(0.0501)	(0.0221)	(0.0752)	(0.0493)
Dent Off/Nur/Tch	-0.434***	-0.205***	-0.166***	0.238*	0.558	0.164*
	(0.0800)	(0.0584)	(0.0558)	(0.182)	(0.414)	(0.158)
Female		0.0174	-0.0120		1.575***	1.123
		(0.0106)	(0.0137)		(0.230)	(0.239)
Years of Experience		0.000434	0.000678		0.996	1.010
		(0.000575)	(0.000609)		(0.00555)	(0.00835)
Total non-ess Q		0.00768***	0.00806***		1.047***	1.070***
		(0.000241)	(0.000404)		(0.00326)	(0.00696)
Constant	0.622***	0.129**	0.0898*	1.493	0.0957***	
	(0.0575)	(0.0549)	(0.0493)	(0.550)	(0.0379)	
Observations	4,120	4,049	4,049	4,120	4,049	1,328
R-squared	0.113	0.454	0.270			
McFadden's Adj R2:				0.070	0.188	0.258
Number of facilities			2,089			375
Hausman test to OLS			chi2=101.65, p=0.0000			chi2=-32.97, p=NA.
Hausman test to RE			chi2=13.60, p=0.3272			chi2=13.80, p=0.3137
Rho			0.4835			0.4981[i]
Number of facilities			2,089			375

Note: Models (1) and (2) are OLS models with facility-level robust clustered standard errors. Model (3) is a facility-level fixed effects model. Models (4) and (5) are logistic regression models with facility-lvel robust clustered standard errors. Model (6) is a facility-level fixed effects logistic regression model. Estimates presented for Models 1-3 are percentage point differences while estimates for models 4-6 are odds ratios. Estimates for models 1,2,4 and 5 are weighted for the inverse probability of selection of the individual health worker. Rho in Model 6 refers to the intraclass correlation across facilities in an equally specified linear probability model. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

DISCUSSION

Within a context of very low overall knowledge, we find that Medical Officers are more likely to know the clinical guidelines for screening of a patient with type II Diabetes when compared to CHOs, CHEWs and JCHEWs but not Nurse Officers or Nurse Midwives. Although Medical Officers have greater knowledge of the guidelines, they are not more accurate in their identification of a hypothetical type II Diabetes case than are all non-physician clinician cadres except for JCHEWs. Our results suggest that all else being equal, non-physician clinicians are equally as likely to know how to identify a case of type II Diabetes as Medical Officers and could hence, take on this role. Low overall knowledge, asking more non-essential questions and facility effects underlie the small or non-existent differences between these cadres.

Our findings contribute to the limited evidence of health worker competence for the identification of diabetes patients and to the even more limited evidence on the ability of non-physician clinicians to undertake this task. In the face of a growing prevalence of type II diabetes [150,151,168,170], studies have attempted to identify important factors to reduce morbidity and mortality of type II Diabetes have often identified low levels of awareness among health workers[155,160,164,166,171,172]. Although a large number of studies have assessed risk factors, prevalence of diabetes and its complications as well as patient knowledge of self-care [163,172–175], we are aware of only one study that compared the clinical competence of non-physician clinicians to physicians in a lower middle income country, finding no difference between these cadres[89].

Our study is not the first to find low levels of diabetes related knowledge among health workers

in Nigeria but it is the first to show that low knowledge spans across health worker cadres. In a study of health workers in southwestern Nigeria, [167] found that among 184 health workers that responded to a diabetes and hypertension knowledge questionnaire, 89% knew that adequate glucose control in diabetes patients decreases the risk of diabetes-related complications although 64.1% knew the target blood glucose level for a diabetes patient. In an other study, [165], assessed the diabetes management ability of health workers, in accordance to international standards, in a teaching hospital in Ilorin, a city in western Nigeria. In a more recent study, [176] found that 86% of the sampled health workers knew that diabetes is a chronic illness with no cure, that 71% knew the fasting glucose level above which to suspect a diagnosis and only 46% knew that a urine test could be used to diagnose the illness.

Our study findings suggest that the simple differences in knowledge we find across cadres are due to differences in facility-level factors as well as differences in the number of non-essential questions asked by a health worker but not to a health worker's gender or experience. Facility-level factors account for over 40% of the variation in our models, suggesting that where a health worker is posted, regardless of their training, can influence their levels of knowledge. Comparable studies that assess health worker knowledge, in other contexts, have found less competent health workers in rural areas [124,131,134] and found differences across public and private facilities [124,135]. Further analysis would be necessary to assess the effects of specific facility differences on health worker knowledge. Evidence from studies that used similar methods to assess health worker knowledge have contradictory findings on the role of experience on knowledge or competence [123,124]. The majority of similar studies have not directly addressed the gender difference in the knowledge for health service provision, those that have, also find conflicting results [89,123,132,138]. It is most likely that the effect of gender and experience on health worker knowledge is very context specific; in Nigeria these factors do not play an

important role.

We consistently found a significant effect of the total number of non-essential questions the health worker asked on their knowledge of diabetes. The fact that this variable is strongly associated with the odds of a correct diagnosis is an indication that perhaps, although health workers who ask more questions, by definition are talking and spending more time on the case than those that do not, these health workers have a higher intrinsic ability or motivation. We are limited by the data that are available in this survey and are hence, are unable to come to a definitive conclusion on the exact meaning of this variable. We do, however, propose two different hypotheses. We hypothesize that this variable is an indication of a health worker's knowledge of other illnesses/diagnoses and that by asking a greater number of additional questions of the patient, they are better able to give a differential diagnosis that has discarded other possibilities. Another hypothesis, possibly related to the previous, is that this variable is an indication of the intrinsic motivation of each health worker; more motivated health workers could display more interest in the case, and be more careful in their diagnoses. Intrinsic motivation could in turn manifest itself in greater knowledge of alternative diagnoses. No other studies using vignettes to measure health worker knowledge have controlled for this specific variable. [177] investigated the issue of intrinsic motivation by comparing health worker performance using vignettes with direct observation of a consultation. They find variations in what they label as professionalism or intrinsic motivation, a measure of the difference between what health workers know and do. They find that more highly professional health workers tend to communicate more with their patients and display higher competence as measured by the vignettes.

CONCLUSION

We find very low overall knowledge of the clinical guidelines and diagnostic accuracy for type II diabetes across all cadres in Nigeria. Although simple differences suggest Medical Officers are much more knowledgeable of diabetes than non-physician clinicians, we find these differences are due to variation in what we believe is an intrinsic ability or motivation of each health worker as well as to facility level factors. Controlling for health worker and facility characteristics, our findings show some differences in the knowledge of clinical guidelines between Medical Officers and non-physician clinicians but no differences in the ability of these cadres to identify a case of diabetes. Our findings suggest that all non-physician clinicians (except JCHEWs) are equally able to identify a case of type II diabetes and could take on this role. The low overall health worker knowledge within a context of a rapidly growing burden of the disease, calls for increased efforts to further train Medical officers and non-physician clinicians working in public primary care to identify and then manage type II Diabetes patients.

Chapter 6: Conclusion

The papers in this dissertation have examined the difference between non-physician clinician's and physician's knowledge of primary health care service standards in Nigeria. Paper 1 assessed health worker differences in three aggregate measures of primary care service standards: knowledge of consultation process guidelines, diagnostic accuracy and knowledge of treatment guidelines. Findings from paper 1 suggest that when controlling for facility and health worker characteristics, there are small but significant differences between Medical Officers and non-physician clinicians in the knowledge of consultation process guidelines, small and, only in some cases significant, differences between these cadres in their diagnostic accuracy, and no significant differences in their knowledge of treatment guidelines.

In Paper 2, we assessed the differences in pneumonia treatment knowledge between non-physician clinicians and Medical Officers in Nigeria. With these analyses we found that although Medical Officers are significantly more knowledgeable of the consultation guidelines and have a significantly higher diagnostic accuracy for pneumonia, they are less but not significantly less knowledgeable of the full treatment guidelines for this illness than are non-physician clinicians. We sought to explain this surprising result by examining differences in knowledge between these cadres, across treatment components and found that no significant differences exist in the knowledge of the recommended, or effective, antibiotic treatment, Medical Officers are slightly but not significantly less likely to prescribe the recommended paracetamol treatment to reduce the child's fever, but Medical Officers are significantly less likely to recommend a child return for follow-up. There is little in the existing literature that illuminates why this might be the case, so the paper raises important questions for further research.

In Paper 3, we examined the differences in health worker knowledge of type II diabetes consultation process guidelines and diagnostic accuracy comparing non-physician clinicians and Medical Officers. Simple differences between cadres suggest that Medical Officers know to ask nearly twice as many consultation process questions and are over twice as likely compared to non-physician clinicians to identify a case of type II diabetes. However when we control for health worker and facility characteristics, we find that Medical Officers are more knowledgeable of the clinical guidelines than CHOs, CHEWs and JCHEW but not Nurse Officers and Nurse Midwives, and are not more likely to identify a case of type II Diabetes than non-physician clinician cadres as a collective group.

Throughout our analyses, we find low overall health worker knowledge. In paper 1, we find that on average, health workers posted to public primary health facilities in Nigeria know to ask 30.1% of the consultation process questions outlined in the clinical guidelines for the five hypothetical cases included in our study. These health workers are able to diagnose under half (47.5%) of the cases that were presented to them and know to provide full-recommended treatment to only 21.7% of the cases. When we look specifically at the treatment of pneumonia, in paper 2, we find that 62.2% of health workers who regularly provide consultations in public primary and secondary health facilities, know to recommend amoxicillin or co-trimoxazole to a child suffering from pneumonia, just over half (59.9%) know to recommend paracetamol and only 19.7% know to recommend the child come back for follow-up. From our study, we find that only 13.0% of these health workers know to recommend the full treatment of pneumonia. In paper 3 we find enormous gaps in the overall health worker's knowledge of consultation process clinical guidelines. On average health workers that regularly provide outpatient consultations in public primary health facilities ask 21.7% of the questions outlined in the

guidelines and only 27.8% of these health workers are able to correctly diagnose a case of type II diabetes

Across all three papers, we find that neither gender nor years of experience are significantly correlated with health worker knowledge but the number of non-essential questions a health worker asks during the vignettes interview is consistently and significantly positively correlated with all our knowledge outcome variables in all our models across the papers. This finding is of particular interest as our studies are the first, to our knowledge, to include such variables in their analyses. Finally throughout our analyses, we also find that facility characteristics explain a large proportion of the variance of all our knowledge outcome variables.

Findings in the context of broader literature

Similar studies comparing performance in health service delivery between non-physician clinicians and higher level health worker cadres, have also found that non-physician clinicians are able to provide similar quality care to higher level cadres [23–25,86,89,178]. Due to the low quality of many task-shifting studies and particularly, sample sizes that are not large enough to adequately detect differences, available evidence on task-shifting is inconclusive. Our results, hence, contribute important robust evidence on the knowledge of non-physician clinicians regarding the provision of primary care as compared to physicians.

Our studies are not the first to point to low levels of health worker knowledge. Studies in low- and middle-income countries, using vignettes to assess health worker knowledge, have found that health workers often misdiagnose illnesses and often do not adhere to clinical guidelines. A study of public and private providers in Delhi, India, [123] used vignettes to assess health worker

knowledge and found that 28% of health workers interviewed were unable to diagnose a case of uncomplicated tuberculosis and 44% were unable to diagnose and refer a standard case of pre-eclampsia. Rao et al (2013)[89] found significant differences in the ability of physician clinicians and non-physician clinicians to correctly diagnose 6 basic conditions in primary care centers in India. Other findings from India, using clinical vignettes showed that for a case of a child with diarrhea only 25% of health workers ask about the presence of blood or mucus in the stool, 49% asked if the child had a fever and only 7% checked for dehydration by checking the skull fontanel [134]. A study in Indonesia found that health workers were less than 50% likely to carry out essential procedures for the diagnosis of a child with diarrhea [133].

Low health worker knowledge could suggest even lower health worker performance, if evidence from other countries applies to the Nigerian context. Over the past decade, a number of studies have explored the differences between health worker knowledge and their performance during consultations, referring to this as the know-do gap [40,177]. Several authors have shown that often, health workers do less when undertaking consultations than they know how to do. Leonard & Masatu (2005) used clinical vignettes to test the knowledge of health workers in Tanzania and then compared the results to those of direct clinical observations in consultations with actual patients. These authors found that the large majority of health workers in the study asked less questions and performed less examinations than they know how to. They also found that, knowledge as measured by clinical vignettes was positively correlated with performance and this relation was stronger for higher cadre health workers. Das & Hammer (2004) conducted a similar study in Delhi, India and found that fewer health workers asked patients about symptoms and performed physical examinations when observed in a consultation than when assessed with clinical vignettes.

Study Limitations

Our studies have two important limitations. The first is the limited representativeness of our sample. Our sample is representative of health workers in public primary and secondary health facilities in 12 Nigerian states. This sample does not allow us to infer beyond the 12 states from which health workers were selected. Although we have no reason to believe that the overall results from our studies should not apply to other states in Nigeria, given the distribution of income and geographic location of the states from which the sample was chosen, we cannot be statistically certain that no systematic differences exist between health workers included in our sample and those of other states. We believe that the inclusion of other states in our sample would have likely led us to similar conclusions but perhaps would have affected our point estimates suggesting larger or smaller differences between cadres. Our sample is restricted to health workers in public primary and secondary health facilities; although health workers often provide services both in the public and private sectors, we cannot be certain that either the direction or the magnitude of our estimates would hold for health workers in the private sector. Similarly, although many other countries have similar contexts in which health workers are trained and work, which could likely lead to similar results, we cannot be certain that what we find could apply in other contexts. For these reasons, we call for further research in other Nigerian states, the private sector and other countries.

The second important limitation to our studies is that of the restrictiveness of our measures. We measure only health worker knowledge, not their performance and not the overall quality of care received by patients. As mentioned above, research on the know-do-gap has shown differences in knowledge and health worker performance [40,177]. Although, from available evidence we can reasonably assume that our estimates of knowledge are an overestimation of

health worker performance when undertaking a consultation, we do not know the extent of the bias across cadres and hence cannot be certain that our conclusions on the differences in knowledge across cadres would equally apply in terms of differences in performance across cadres. Although studies that use health worker observation to assess performance, have their own biases and are even more costly, we believe they would provide a closer approximation of differences in health worker performance for task shifting, than we are able to provide with this study.

Policy Implications

Nigeria's new task-shifting policy [36] is a response to the chronic shortage and maldistribution of physicians and nurses in the country. The document acknowledges the difficulties in their retention within the country and in rural areas as well as the challenges for the production of significantly larger numbers of these health workers in the near future [36]. Within a larger context of policies that aim to steer the country towards Universal Health Coverage [180], the Nigerian Federal Ministry of Health has seen an opportunity to move towards these goals by using what they refer to as an "untapped resource" of Community Health Extension Workers (CHOs, CHEWs and JCHEWs) and available nurses to provide primary care services [36]. Although the authors of the task-shifting policy used all available evidence on the ability of non-physician clinician cadres in Nigeria to undertake tasks traditionally assigned to physicians [36], evidence is scant and the policy relies on the hope that these cadres are in fact a solution to human resources problems that currently plague the country. Our studies are the first to present evidence from across the country that specifically questions the knowledge of non-physician

clinicians to undertake the roles that have now been formally assigned to them. This evidence can, hence, feed directly into the implementation of the policy and help guide expectations.

Evidence from our studies supports the Nigerian task-shifting policy as a potential solution to the shortages and maldistribution of physicians in the country. Our findings suggest that non-physician clinicians have levels of knowledge that are not significantly different from that of available Medical Officers for the provision of primary care, pneumonia treatment and even the screening of type II diabetes. Our findings suggest that Nigeria's Community Health Extension Worker scheme is indeed producing health workers who are knowledgeable enough to deliver primary health services of equal quality as those delivered by physicians.

Our findings support the task shifting policy as a strategy for reaching Universal Health Coverage in Nigeria, however, much more needs to be invested in supportive supervision and training[65,181]. Our findings point to large gaps in knowledge of consultation guidelines, diagnostic accuracy and knowledge of treatment guidelines across all health worker cadres for all hypothetical illnesses presented to them in our study. The task-shifting policy includes recommendations for improvements in training, supervision and overall quality assurance; our findings highlight the importance of these recommendations as supplementary measures for the goal of increased coverage and goals of quality of care to be reached.

Although our findings are specific to Nigeria, the implications of these can be far-reaching. Task-shifting has increasingly become important within discussions of issues of human resources for health [5,66] and has been seen as a promising strategy to tackle health worker shortages and maldistribution within low- and middle-income countries [69,118]. With a number of circumstances similar to those of other sub-Saharan African countries, results from these studies could

provide broader, regional lessons. Many other countries in the region also suffer from chronic health worker shortages [3,182], from a high burden of communicable diseases while also beginning to face a growing prevalence of non-communicable illnesses [183]. Many countries in the region also have small health budgets[184], but have long-standing non-physician clinician cadres [6]. In sub-Saharan Africa, at least 25 countries have non-physician clinician cadres that are trained to provide primary care, and could, as in Nigeria, take on greater responsibilities for the delivery of these services in the absence of higher-level cadres [6].

Despite the call for task-shifting strategies and the pervasiveness of non-physician clinician cadres across the continent, there is very little recent evidence on the performance of non-physician clinicians as compared to physicians, for the delivery of primary care (refer to literature review in Chapter 2). It is within this context that our studies contribute evidence to the broader discussion. Evidence from our studies supports task-shifting as a strategy to provide primary health services in contexts of physician shortages, but cautions against relying on non-physician clinicians for the provision of health services under high standards for quality of care. Although further research is needed to identify important factors that could increase health worker knowledge of clinical guidelines within specific contexts, our results suggest that characteristics of the facility and the number of non-essential questions a health worker asks during consultations can play an important role for health worker knowledge, likely, within any country context. In our studies, we find that facility level characteristics can explain nearly half of the variation in health knowledge regardless of the outcome measure of our model. Although there are a myriad of possible specific facility characteristics that could be important to health worker knowledge, such as facility type, location, how well stocked the facility is, how many other health workers it has or the levels or quality of supervision, these factors could have different effects in different countries or contexts. From our results, it is clear that the context in

which a health worker is posted needs to be carefully considered for the design of task-shifting policies.

We also find that health workers who ask a greater number of non-essential questions during the interview, display higher levels of knowledge across our different studies. These are the first studies of this kind, to include such a variable in their models for health worker knowledge or performance. We hypothesize that this variable represents an intrinsic ability or motivation of a health worker and although the sources of ability and motivation might vary across different country contexts, we believe that exploring this with further research would be important for defining ways to improve health worker knowledge and potentially, the quality of health service provision. Health worker motivation across the region has been widely discussed [185,186] but little is known about the extent to which motivation and knowledge or quality of service provision are linked [187].

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ANNEXES

Annex I: Note on Study Sampling strategy

The Nigerian Service Delivery Indicator Survey used stratified random sampling to select health facilities. The sampling frame from which the sample was drawn, was the Federal Government's list of all Nigerian public health facilities. Facilities were categorized as primary, secondary or tertiary level in accordance with Ministry of Health Records. The Local Government Area where the facilities are located was categorized as urban, semi-urban or rural based on the latest available census information (2006). The 12 states included in the study were selected from across the north, center and south regions of the country based on interest and agreement between the World Bank and the Nigerian Federal Ministry of Health. For each of the 12 states, using the sampling frame of public health facilities, facilities were stratified by urban/semi-urban and rural location and primary and secondary level of care, creating 4 strata for each state. Given the smaller number (25-50) of secondary health facilities in each state, all were included in the sample. The sample size for health facilities within each rural and urban/semi-urban strata was calculated using the following formula to detect a difference in proportions of 20% points, with 95% confidence and 80% power, assuming, for caution a proportion of 50%:

$$m = \frac{(Z_{\alpha/2} + Z_{\beta})^2 * (p_1(1-p_1) + p_2(1-p_2))}{(p_1 - p_2)^2}$$
$$= \frac{(1.96 + 0.84)^2 * ((0.5)(1-0.5) + (0.7)(1-0.7)}{(0.5 - 0.7)^2} = 91$$

For each strata the sample size calculation was adjusted by the total (finite) number of health facilities in the sampling frame using the following formula:

$n = \frac{m}{1+\frac{m-1}{N}}$, where N is the total number of health facilities in the strata.

Although there is variation in the total number of health facilities across states and hence within each strata, the number of facilities in the sampling frame, per strata, did not exceed 400:

$$n = \frac{m}{1 + \frac{m-1}{N}} = \frac{91}{1 + \frac{91-1}{400}} = 74$$

The final sample size of facilities needed for each state was of 74 primary health facilities from rural areas, 74 primary health facilities from urban or semi-urban facilities and all (25-50) secondary facilities, for a maximum total of 198 facilities per state.

Annex II: Note on regression models used for analysis

The theoretical model behind our analyses relies on an understanding of health worker knowledge arising from a combination of individual health worker characteristics and the characteristics of the environment where they work.

$$knowledge_i = \sum(individual\ characteristics)_i + \sum(contextual\ factors)_i + \epsilon$$

We define individual characteristics as innate or acquired characteristics of the health worker such as age, gender, experience, motivation, type of training, years in training and. We define contextual factors as those related to the work environment which can include the type of facility where the health worker is posted, the location of the facility, structural qualities of the facility (availability of water, electricity, medicines, etc), the management and/or supervision of the facility, the population the facility serves, etc.

Across our analyses we wished to estimate the effect of a health worker's cadre on their knowledge of consultation process clinical guidelines or their diagnostic accuracy.

The basic model in our analysis is the following:

$$knowledge_{if} = \beta_0 + \beta_1 cadre_{if} + \beta_2 gender_{if} + \beta_3 experience_{if} + \beta_4 questions_{if} + \alpha_f + u_{if}$$

where α_f represents the unobserved facility characteristics that are common to individual (i) health workers in a given facility *f*. In order to control for these clustered unobserved facility

characteristics, we use fixed effects models to estimate the differences in health worker's knowledge posted to the same facility. The resulting fixed effects model is the following:

$$\Delta knowledge = \beta_1 \Delta cadre + \beta_2 \Delta gender + \beta_3 \Delta experience + \beta_4 \Delta questions + \Delta u$$

Under the assumptions that we have no unobserved individual characteristics and that the α_f variable is correlated with one or more of the explanatory variables included in the model, our fixed effects model estimates are efficient and unbiased.

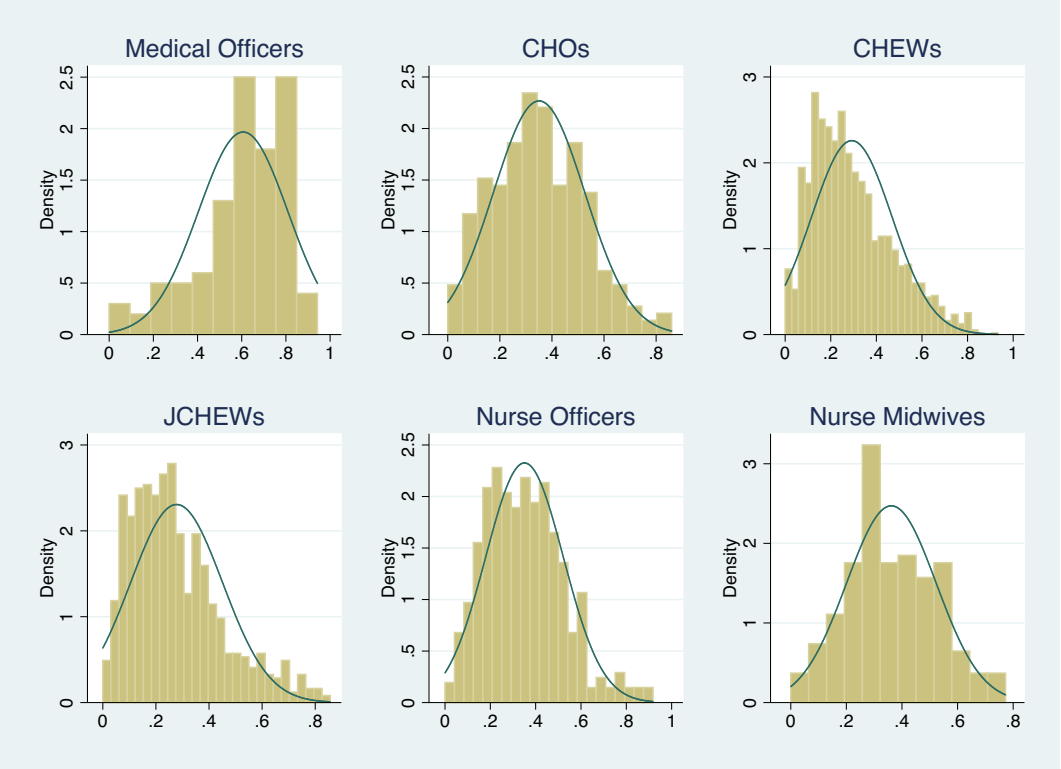
Annex III: Paper 1 additional tables and figures

Consultation process

Table 16: Percentage of consultation process (history and physical examination) questions asked for each case, by cadre

	Acute diarrhea with severe dehydration- *13 month old boy with diarrhea*			**Pneumonia-** *5 year old girl with a cough*			**Malaria with Anemia -** *4 year old boy with fever for some time that is now worse*			**Diabetes Type II -** *48 year old man feeling weak, without energy and is often hungry*			**Pulmonary Tuberculosis-** *40 year old man suffering from fever and cough for some time*		
History and physical examination questions	-Frequency of Diarrhea - Consistency of stool -Vomiting -General condition (weakness) -General health condition (awake, lethargic, tiredness, fatigue) -Skin pinch -Offer drink -Sunken eyes			-Presence of difficulty in breathing -Difficulty in swallowing -Count respiratory rate -Observe breathing for lower chest wall in-drawing -Auscultate the chest -Take temperature			-Convulsions -Vomiting -Appetite -Responsiveness/ General condition -Temperature -Neck stiffness -Eyes, sunken?			-Thirst -Urinary output -Weight -Urinalysis			-Duration of cough -Productive cough -Blood in sputum/color of sputum -Breathlessness/ shortness of breadth -Chest pain/difficulty breathing -Weight loss		
	N	% Q	CI	N	% Q	CI	N	% Q	CI	N	% Q	CI	N	% Q	CI
Cadre															
Medical Officer	108	57.6	(51.1-64.1)	108	52.9	(45.8-60.0)	107	62.2	(50.8-73.7)	106	67.8	(60.8-74.7)	106	43.7	(37.5-49.9)
CHO	256	41.5	(37.4-45.7)	256	34.6	(30.0-39.2)	256	26.7	(21.8-31.5)	255	42.9	(38.8-47.0)	253	30.6	(27.2-34.0)
Nurse Officer	494	39.3	(36.7-41.9)	494	29.4	(26.7-32.1)	494	36.0	(31.8-40.1)	494	44.9	(41.8-47.9)	494	29.1	(26.8-31.4)
Nurse Midwife	168	40.2	(34.4-46.1)	168	29.6	(24.9-34.3)	168	30.7	(23.5-38.1)	168	43.3	(38.0-48.6)	168	27.4	(23.6-31.2)
CHEW	1889	34.5	(33.1-35.9)	1889	26.4	(25.1-27.8)	1889	19.3	(17.8-20.8)	1888	36.7	(35.1-38.2)	1886	29.2	(27.9-30.6)
JCHEW	799	32.3	(30.4-34.3)	799	22.6	(20.8-24.5)	799	14.6	(12.7-16.6)	799	37.8	(35.7-40.0)	799	28.5	(26.5-30.5)
Env Hlth Off/Ass	110	30.9	(26.7-35.0)	110	21.1	(16.1-26.1)	110	13.6	(8.3-18.8)	110	36.7	(30.5-42.8)	110	27.7	(21.9-33.6)
Comm Hlth Ass	93	24.4	(18.3-30.5)	93	15.0	(11.6-18.5)	93	11.4	(6.4-16.3)	93	28.1	(21.6-34.6)	92	19.9	(15.2-24.5)
Hlth Att/AuxNurse	168	22.8	(19.2-26.3)	168	12.2	(9.5-15.0)	167	8.2	(5.1-11.3)	168	27.7	(22.9-32.4)	168	20.0	(16.5-23.5)
Dent Off/Nur/Tech	37	33.0	(21.7-44.4)	37	27.0	(12.6-41.4)	37	18.9	(6.1-31.6)	36	35.7	(27.5-44.0)	36	22.1	(12.8-31.4)
All	4,122	35.1	(34.1-36.1)	4,122	26.3	(25.4-27.3)	4,120	21.7	(20.5-22.9)	4,117	38.8	(37.8-39.9)	4,112	28.8	(27.9-29.6)
Cronbach's alpha		0.7796			0.788			0.7912			0.7692			0.7783	
Av inter-item corr		0.4693			0.4817			0.4865			0.4545			0.4674	
Overall alpha		0.8171													
Overall int-it corr		0.4719													

Figure 8: Distribution of percentage of consultation process questions by cadre

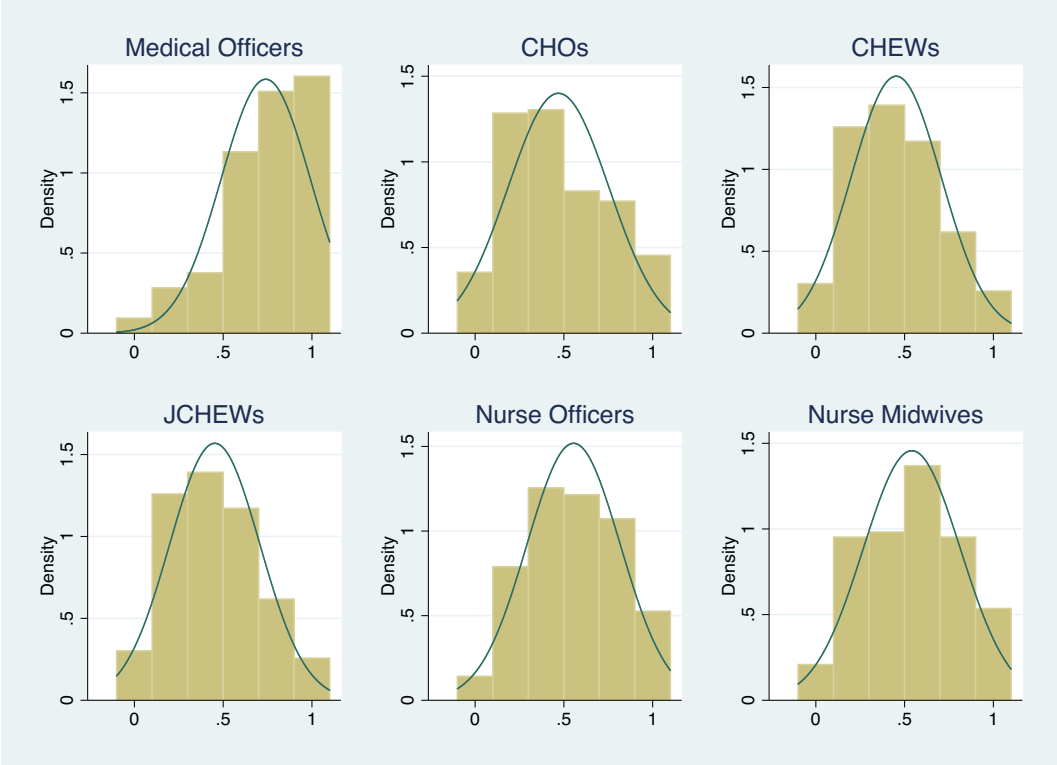


Diagnostic Accuracy

Table 17: Percentage of health workers that correctly diagnose each case, by cadre

	Acute diarrhea with severe dehydration- *13 month old boy with diarrhea*			**Pneumonia**- *5 year old girl with a cough*			**Malaria with Anemia** - *4 year old boy with fever for some time that is now worse*			**Diabetes Type II** - *48 year old man feeling weak, without energy and is often hungry*			**Pulmonary Tuberculosis**- *40 year old man suffering from fever and cough for some time*		
	N	%	CI	N	%	CI	N	%	CI	N	%	CI	N	%	CI
Cadre															
Medical Officer	108	49.2	(33.9-64.6)	108	72.0	(57.0-86.9)	107	59.9	(44.2-75.5)	106	85.4	(76.0-94.8)	106	95.1	(90.7-99.6)
CHO	256	33.8	(25.2-42.5)	256	49.5	(40.6-58.5)	256	30.9	(22.0-39.8)	255	62.9	(54.8-71.0)	253	88.7	(83.9-93.6)
Nurse Officer	494	30.0	(24.0-36.0)	494	45.8	(39.4-52.1)	494	52.1	(45.7-58.5)	494	66.6	(61.0-72.2)	494	91.1	(87.3-95.0)
Nurse Midwife	168	35.9	(21.3-50.6)	168	44.0	(30.5-57.4)	168	49.3	(35.4-63.2)	168	64.8	(51.8-77.8)	168	90.5	(85.1-95.9)
CHEW	1889	25.6	(22.8-28.5)	1889	39.2	(36.2-42.3)	1889	24.1	(21.2-27.0)	1888	56.4	(53.2-59.5)	1886	86.5	(84.5-88.6)
JCHEW	799	18.8	(15.2-22.5)	799	38.8	(33.5-44.2)	799	18.4	(14.2-22.7)	799	52.4	(47.2-57.7)	799	86.9	(83.7-90.0)
Env Hlth Off/Ass	110	32.3	(18.7-45.9)	110	36.1	(22.7-49.6)	110	21.3	(10.1-32.6)	110	54.8	(41.0-68.6)	110	72.5	(58.8-86.3)
Comm Hlth Ass	93	12.2	(4.3-20.1)	93	21.4	(12.3-30.5)	93	9.2	(2.6-15.8)	93	31.0	(20.0-42.0)	92	82.6	(73.0-92.1)
Hlth Att/AuxNurse	168	12.1	(6.0-18.2)	168	14.8	(8.8-20.9)	167	5.8	(1.6-10.0)	168	32.0	(23.0-41.0)	168	86.1	(80.4-91.8)
Dental Off/Nur/Tech	37	44.4	(20.2-68.6)	37	33.3	(9.3-57.3)	37	26.2	(2.2-50.3)	36	80.3	(65.5-95.0)	36	82.8	(66.1-99.5)
All	4,122	25.8	(23.8-27.8)	4,122	40.0	(37.8-42.2)	4,120	27.8	(25.7-29.9)	4,117	56.8	(54.6-59.0)	4,112	87.2	(85.8-88.6)
alpha		0.1911			0.1953			0.1625			0.1761			0.2482	
Av inter-item corr		0.4858			0.4926			0.4369			0.461			0.5691	
Overall alpha		0.1946													
Ovrall int-item corr		0.5472													

Figure 9: Distribution of percentage of cases correctly diagnosed, by cadre

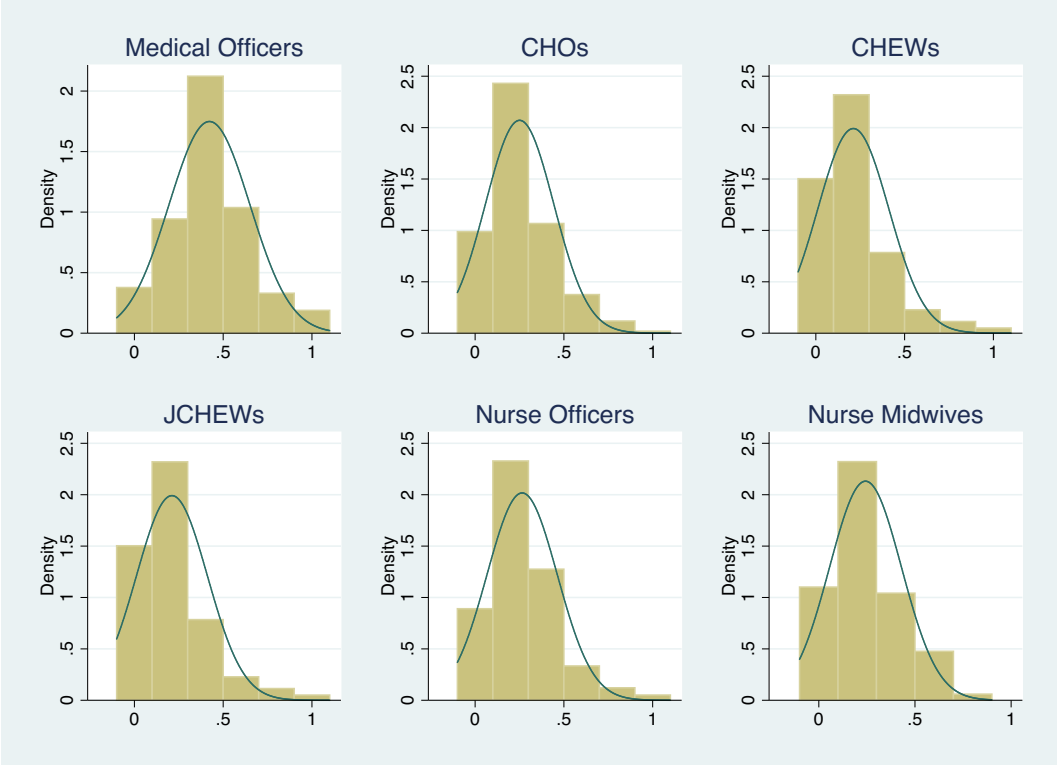


Treatment Knowledge

Table 18: Percentage of health workers that correctly treat each case, by cadre

	Acute diarrhea with severe dehydration- 13 month old boy with diarrhea			**Pneumonia- 5 year old girl with a cough**			**Malaria with Anemia - 4 year old boy with fever for some time that is now worse**			**Diabetes Type II - 48 year old man feeling weak, without energy and is often hungry**			**Pulmonary Tuberculosis- 40 year old man suffering from fever and cough for some time**		
Correct treatment	-Rehydration using Oral Rehydration Salts AND -100ml/kg Ringer Lactate Solution			-Cotrimoxazole 1 tab bd 5/7 OR -Amoxicillin 250 mg qds x5 AND -Paracetamol 250 mg qds x 5 days -Ask parent to bring child in 2 days			-Paracetamol AND -Adeq fluids and nutrition AND -Artemizinin combination OR -Chloroquine 1.5t x d x 3d OR -Quinine IM inj OR -Artesunate Amodiaquin			-Follow-up at specialist outpatient clinic OR -Refer to higher level health facility for further management [Only if Medical officer: -Oral hypoglycemic OR -Insulin]			-Combination therapy: Rimactizide & Rimfampicine, Ethambutol & Pyrazinamide for 4 months, and Ethambutol & Isoniazide for 2 months OR -Follow-up in the TB clinic OR -Refer to higher level facility		
	N	%	CI	N	%	CI	N	%	CI	N	%	CI	N	%	CI
Cadre															
Medical Officer	108	28.8	(14.0-43.7)	108	11.6	(2.0-21.3)	107	71.4	(57.0-85.8)	106	85.1	(76.6-93.6)	106	20.9	(7.4-34.3)
CHO	256	9.4	(4.5-14.3)	256	19.3	(11.2-27.4)	256	15.9	(10.4-21.4)	255	71.0	(62.4-79.5)	253	10.5	(4.3-16.7)
Nurse Officer	494	12.2	(8.1-16.4)	494	12.8	(8.7-16.9)	494	22.4	(17.3-27.5)	494	73.2	(67.6-78.9)	494	14.4	(10.0-18.8)
Nurse Midwife	168	9.3	(3.8-14.9)	168	10.9	(-1.6-23.5)	168	16.7	(9.7-23.7)	168	76.5	(67.6-85.3)	168	17.5	(4.7-30.3)
CHEW	1889	7.8	(6.1-9.6)	1889	11.3	(9.3-13.3)	1889	12.9	(10.5-15.4)	1888	61.5	(58.4-64.6)	1886	9.6	(7.6-11.7)
JCHEW	799	8.3	(5.7-10.9)	799	10.8	(8.0-13.6)	799	10.2	(7.7-12.8)	799	57.4	(52.3-62.4)	799	9.6	(7.0-12.3)
Env Hlth Off/Ass	110	12.0	(5.5-18.5)	110	6.8	(2.6-11.0)	110	16.6	(6.0-27.3)	110	46.4	(33.0-59.8)	110	8.8	(0.7-17.0)
Comm Hlth Ass	93	3.6	(-0.5-7.7)	93	3.5	(-1.1-8.1)	93	7.8	(0.9-14.7)	93	48.6	(36.2-61. 1)	92	5.4	(0.1-10.7)
Hlth Att/AuxNur	168	3.5	(-1.19-8.2)	168	6.2	(1.2-11.2)	167	7.1	(2.6-11.6)	168	41.9	(32.6-51.3)	168	1.0	(-0.3-2.2)
Den Off/Nur/Tech	37	0.6	(-0.6-1.9)	37	15.4	(1.3-29.5)	37	4.8	(-3.4-13.1)	36	82.8	(70.2-95.4)	36	2.2	(-1.1-5.6)
All	4,122	9.0	(7.7-10.2)	4,122	11.4	(10.0-12.9)	4,120	15.0	(13.4-16.6)	4,117	62.6	(60.5-64.7)	4,112	10.5	(9.0-11.9)
alpha		0.178			0.1998			0.1846			0.2267			0.1757	
Av inter-item corr		0.4642			0.4997			0.4753			0.5397			0.4603	
Overall alpha		0.193													
Ovrall int-it corr		0.5446													

Figure 10: Distribution of percentage of cases correctly treated, by cadre



Other relevant regression models

Table 19: Consultation Process (history taking and physical examination): OLS, FE and RE models

VARIABLES	(1) OLS	(2) OLS-HW Characteristics	(3) FE-HW Characteristics	(4) RE-HW Characteristics
Cadre				
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	-0.217***	-0.0600***	-0.0584***	-0.0577***
	(0.0445)	(0.0160)	(0.0223)	(0.0120)
Nurse Officer	-0.210***	-0.0481***	-0.0468**	-0.0478***
	(0.0367)	(0.0151)	(0.0205)	(0.0111)
Nurse Midwife	-0.225***	-0.0656***	-0.0557**	-0.0439***
	(0.0408)	(0.0183)	(0.0244)	(0.0139)
CHEW	-0.275***	-0.0834***	-0.0817***	-0.0834***
	(0.0365)	(0.0137)	(0.0205)	(0.0105)
JCHEW	-0.296***	-0.0971***	-0.0956***	-0.0965***
	(0.0374)	(0.0140)	(0.0207)	(0.0107)
Env Hlth Off/Ass	-0.308***	-0.102***	-0.110***	-0.0989***
	(0.0430)	(0.0159)	(0.0243)	(0.0134)
Comm Hlth Ass	-0.370***	-0.117***	-0.0998***	-0.104***
	(0.0461)	(0.0151)	(0.0229)	(0.0126)
Hlth Att/AuxNurse	-0.385***	-0.0939***	-0.0688***	-0.0946***
	(0.0394)	(0.0159)	(0.0220)	(0.0118)
Dental Off/Nur/Tech	-0.327***	-0.127***	-0.115***	-0.106***
	(0.0487)	(0.0177)	(0.0239)	(0.0151)
Gender				
Female		-0.0192***	-0.0153**	-0.0210***
		(0.00426)	(0.00670)	(0.00337)
Experience				
<8 yrs experience		-0.00116	0.000986	-0.00118
		(0.00108)	(0.00139)	(0.000799)
8+ yrs experience		0.000741	-0.00185	0.000891
		(0.00122)	(0.00162)	(0.000915)
Non-essential questions				
Total non-ess Q		0.00975***	0.00939***	0.0101***
		(0.000281)	(0.000475)	(0.000221)
Total non-ess Q^2		-3.18e-05***	-2.65e-05***	-3.27e-05***
		(2.34e-06)	(4.34e-06)	(2.03e-06)
Constant	0.568***	0.126***	0.112***	0.117***
	(0.0367)	(0.0158)	(0.0244)	(0.0119)
Observations	4,111	4,040	4,040	4,040
R-squared	0.113	0.734	0.559	
Rho			0.5157	0.1816
Number of facilities			2,086	2,086

Note: [a:] Hausman specification test for comparison between Fixed Effects (model 3) and Random Effect (model 4) models is chi2=10.97 (p=0.6134). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Standard errors for OLS and Random effects models are clustered at the facility level since there is multicollinearity of endogenous variables at the facility level.

Table 20: Diagnostic Accuracy: OLS, FE, RE models

VARIABLES	(1) OLS	(2) OLS-HW Characteristics	(3) FE-HW Characteristics	(4) RE-HW Characteristics
Cadre				
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	-0.189***	-0.0453	-0.139*	-0.133***
	(0.0662)	(0.0372)	(0.0750)	(0.0264)
Nurse Officer	-0.151***	0.00240	-0.0914	-0.0367
	(0.0533)	(0.0315)	(0.0721)	(0.0233)
Nurse Midwife	-0.153***	-0.00505	-0.113	-0.0423
	(0.0580)	(0.0344)	(0.0761)	(0.0286)
CHEW	-0.258***	-0.0834***	-0.183**	-0.130***
	(0.0490)	(0.0287)	(0.0726)	(0.0218)
JCHEW	-0.291***	-0.112***	-0.211***	-0.156***
	(0.0508)	(0.0304)	(0.0723)	(0.0225)
Env Hlth Off/Ass	-0.288***	-0.105***	-0.276***	-0.146***
	(0.0544)	(0.0366)	(0.0783)	(0.0275)
Comm Hlth Ass	-0.409***	-0.179***	-0.239***	-0.192***
	(0.0604)	(0.0394)	(0.0769)	(0.0289)
Hlth Att/AuxNurse	-0.419***	-0.151***	-0.205***	-0.177***
	(0.0527)	(0.0323)	(0.0767)	(0.0255)
Dent Off/Nur/Tch	-0.252***	-0.0717	-0.200***	-0.150***
	(0.0678)	(0.0463)	(0.0774)	(0.0378)
Gender				
Female		-0.0308***	-0.0160	-0.0417***
		(0.0108)	(0.0144)	(0.00800)
Experience				
<8 yrs experience		8.02e-05	0.00270	0.00158
		(0.00249)	(0.00283)	(0.00178)
8+ yrs experience		-0.00112	-0.00383	-0.00198
		(0.00282)	(0.00321)	(0.00204)
Non-essential questions				
Total non-ess Q		0.00976***	0.0100***	0.00875***
		(0.000745)	(0.00101)	(0.000515)
Total non-ess Q^2		-3.73e-05***	-3.72e-05***	-3.04e-05***
		(6.85e-06)	(8.29e-06)	(4.56e-06)
Constant	0.722***	0.308***	0.352***	0.353***
	(0.0488)	(0.0341)	(0.0763)	(0.0249)
Observations	4,111	4,040	4,040	4,040
R-squared	0.083	0.332	0.259	
Rho			0.5950	0.3413
Number of facilities			2,086	2,086

Note: [a:] Hausman test for difference between coefficient in Fixed Effects (model 3) and Random Effect (model 4) models is chi2=36.37 (p=0.0005). Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

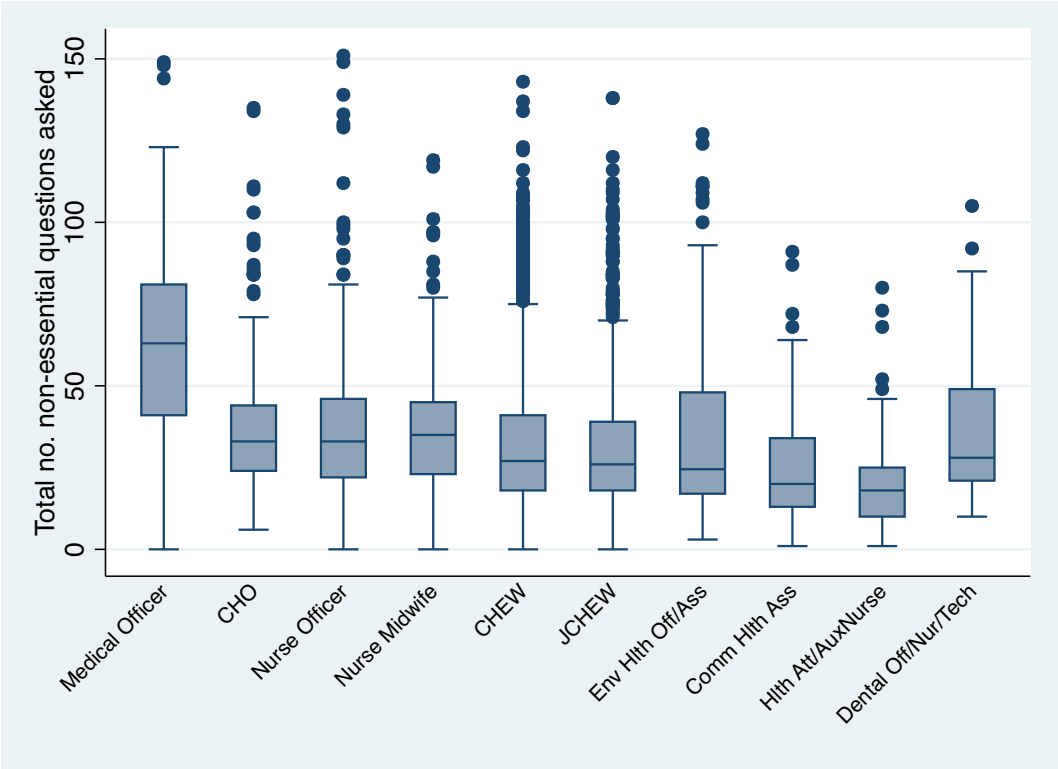
Table 21: Correct Treatment: OLS, FE, RE models

VARIABLES	(1) OLS	(2) OLS-HW Characteristics	(3) FE-HW Characteristics	(4) RE-HW Characteristics
Cadre				
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	-0.184***	-0.0224	-0.0222	0.0304
	(0.0513)	(0.0293)	(0.0426)	(0.0227)
Nurse Officer	-0.165***	-0.000629	-0.0258	0.0551**
	(0.0495)	(0.0297)	(0.0423)	(0.0221)
Nurse Midwife	-0.174***	-0.000347	-0.0338	0.0268
	(0.0546)	(0.0302)	(0.0442)	(0.0232)
CHEW	-0.229***	-0.0435	-0.0603	0.0111
	(0.0498)	(0.0266)	(0.0404)	(0.0208)
JCHEW	-0.243***	-0.0490*	-0.0784*	0.00299
	(0.0499)	(0.0264)	(0.0412)	(0.0212)
Env Hlth Off/Ass	-0.254***	-0.0580*	-0.0649	0.0349
	(0.0581)	(0.0303)	(0.0451)	(0.0250)
Comm Hlth Ass	-0.297***	-0.0707**	-0.120***	-0.0261
	(0.0559)	(0.0297)	(0.0444)	(0.0236)
Hlth Att/AuxNurse	-0.315***	-0.0557*	-0.104**	-0.00806
	(0.0512)	(0.0295)	(0.0426)	(0.0237)
Dent Off/Nur/Tch	-0.217***	-0.0239	-0.0413	-0.0119
	(0.0555)	(0.0348)	(0.0495)	(0.0299)
Gender				
Female		-0.00800	-0.0140	-0.0101*
		(0.00912)	(0.0123)	(0.00580)
Experience				
<8 yrs experience		0.00161	0.00313	0.000541
		(0.00211)	(0.00261)	(0.00136)
8+ yrs experience		-0.00197	-0.00288	-0.000677
		(0.00247)	(0.00296)	(0.00156)
Non-essential questions				
Total non-ess Q		0.00414***	0.00300***	0.00364***
		(0.000521)	(0.000802)	(0.000410)
Total non-ess Q^2		1.77e-05***	1.52e-05*	2.13e-05***
		(5.34e-06)	(8.78e-06)	(4.06e-06)
Constant	0.435***	0.0812***	0.132***	0.0493**
	(0.0492)	(0.0285)	(0.0435)	(0.0224)
Observations	4,111	4,040	4,040	4,040
R-squared	0.058	0.419	0.185	
Rho			0.5241	0.1935
Number of facilities			2,086	2,086

Note: [a:] Hausman test for difference between coefficient in Fixed Effects and Random Effect models is chi2= 24.86 (p=0.0360). Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

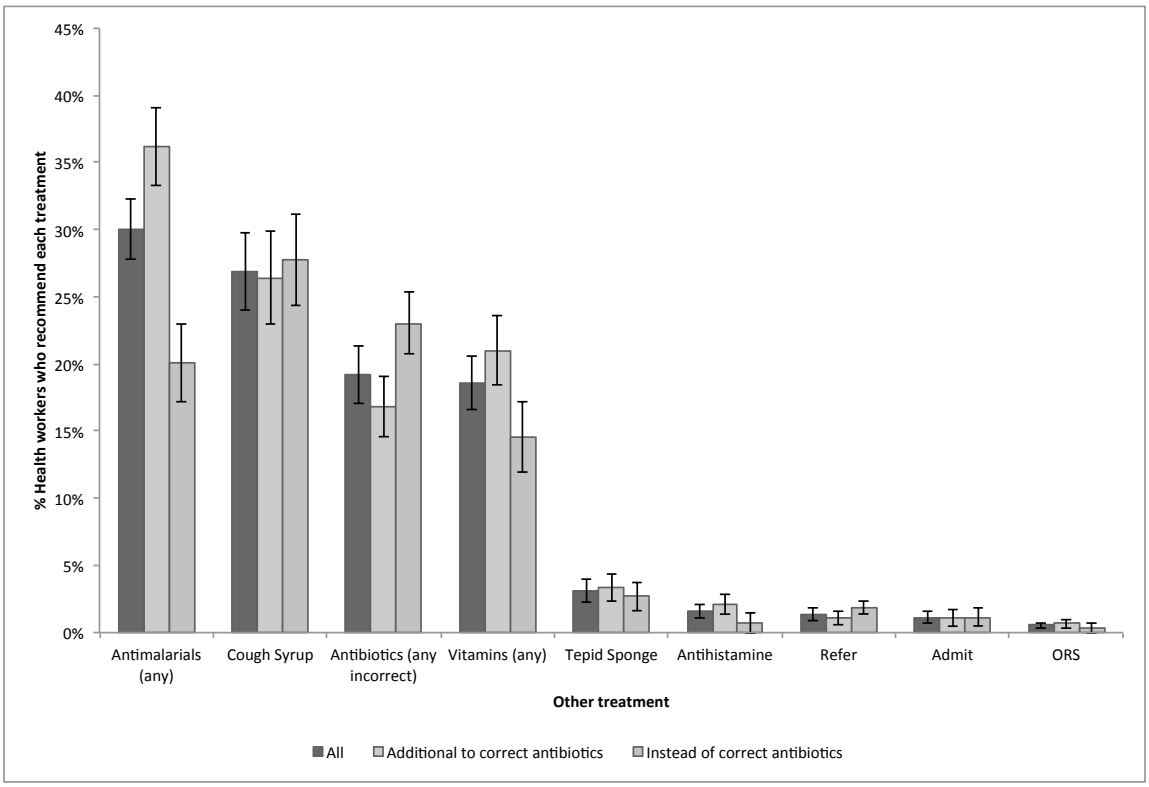
Non-Essential questions, distribution across cadres

Figure 11: Total number of non-essential questions asked by cadre



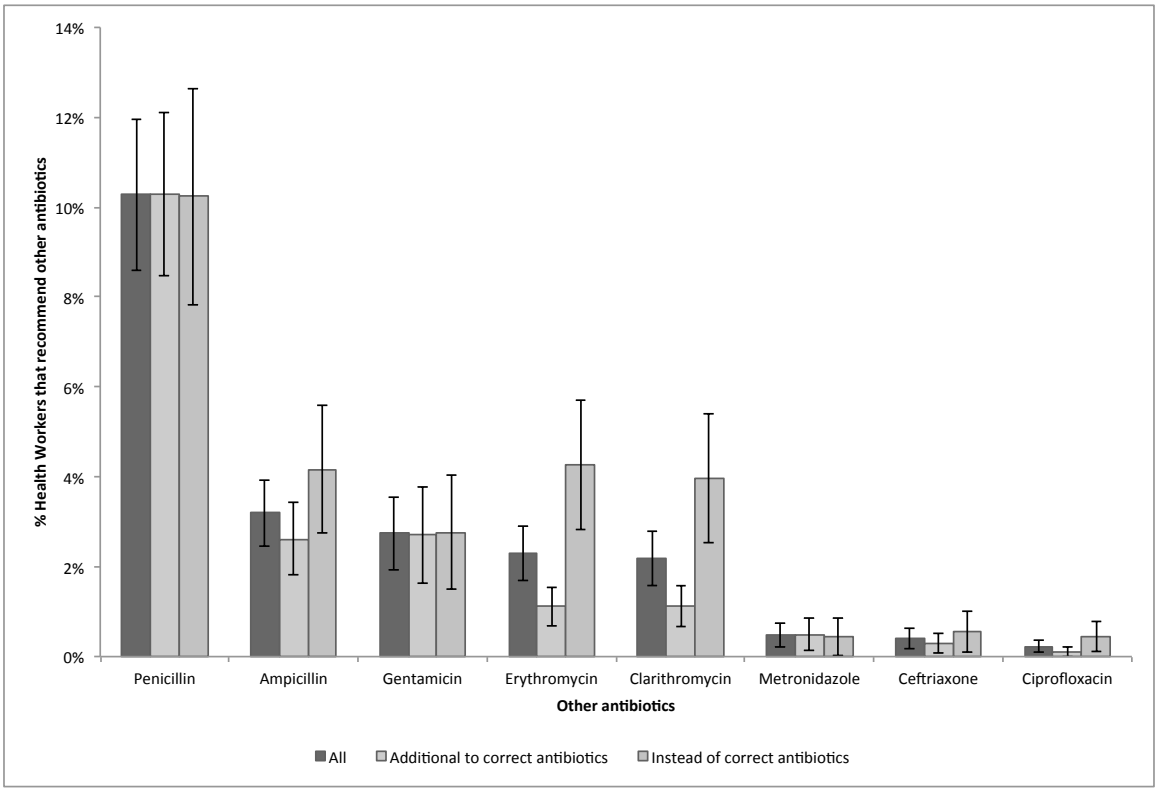
Annex IV: Paper 2 Additional Figures and tables

Figure 12: What other treatment for pneumonia is prescribed?: Percentage of health workers who prescribe other common treatment for a case of Pneumonia, instead of or in addition to prescribing correct antibiotics



Note: The figure above depicts the frequency of prescription of the most commonly recommended treatment for the case of pneumonia for all health workers, health workers who prescribed the correct antibiotics and health workers who did not prescribe the correct antibiotics. Additional to correct is hence defined as the percentage of health workers (n= 2,965) who prescribed each treatment among those that also prescribed either amoxicillin or co-trimoxazole. Instead of correct is defined as the percentage of health workers (n=1,802) who prescribe each of the treatments among those that did not prescribe the correct antibiotic. Treatments are not exclusive of each other. Antimalarials are recommended for all children presenting with a fever. Percentages represent weighted means.

Figure 13: What other antibiotics are commonly prescribed by health workers to treat pneumonia?: Percentage of health workers who prescribe each antibiotic instead or in addition to the recommended antibiotic for the treatment of pneumonia.



Note: The antibiotics included in this figure are the most commonly incorrectly prescribed antibiotics for the treatment of pneumonia. Additional to correct is defined as the percentage of health workers (n=2,965) who prescribe each antibiotic in addition to prescribing amoxicillin or co-trimoxazole. Instead of correct is defined as the percentage of health workers (n=1,802) who prescribe each antibiotic instead of the two that are recommended for the treatment of pneumonia. All is defined as the percentage of all health workers (n=4,767) who prescribe the incorrect antibiotic regardless of their correct/incorrect prescription. The percentage prescription for each antibiotic is exclusive of each of the other prescriptions; health workers in this sample prescribe up to 5 antibiotics at a time. All percentages represent weighted means.

Table 22: Estimated difference in percentage of pneumonia consultation questions asked across cadres. OLS, FE and RE models

VARIABLES	(1) OLS	(2) OLS with health worker characteristics	(3) OLS FE with health worker characteristics	(4) OLS RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	0.802***	0.961**	0.966	0.960***
	(0.0167)	(0.0161)	(0.0236)	(0.0141)
Nurse Officer	0.780***	0.909***	0.931***	0.914***
	(0.0126)	(0.0119)	(0.0164)	(0.0103)
Nurse Midwife	0.816***	0.940***	0.934***	0.938***
	(0.0236)	(0.0166)	(0.0227)	(0.0151)
CHEW	0.746***	0.913***	0.920***	0.914***
	(0.0116)	(0.0112)	(0.0182)	(0.00952)
JCHEW	0.726***	0.889***	0.902***	0.891***
	(0.0119)	(0.0114)	(0.0193)	(0.0101)
Env Hlth Off/Ass	0.733***	0.874***	0.896***	0.874***
	(0.0201)	(0.0160)	(0.0283)	(0.0167)
Comm Hlth Ass	0.672***	0.858***	0.878***	0.864***
	(0.0157)	(0.0149)	(0.0293)	(0.0183)
Hlth Att/AuxNurse	0.658***	0.860***	0.931**	0.869***
	(0.0130)	(0.0144)	(0.0259)	(0.0144)
Dent Off/Nur/Tch	0.745***	0.894***	0.935*	0.900***
	(0.0304)	(0.0284)	(0.0367)	(0.0251)
Female		1.003	1.001	1.002
		(0.00597)	(0.00945)	(0.00580)
Years of Experience		1.000*	1.000	1.000
		(0.000287)	(0.000375)	(0.000274)
Total non-ess Q		1.006***	1.006***	1.006***
		(0.000119)	(0.000234)	(0.000114)
Constant	1.745***	1.186***	1.129***	1.179***
	(0.0254)	(0.0165)	(0.0245)	(0.0140)
Observations	5,059	4,957	4,957	4,957
R-squared	0.159	0.475	0.295	
Number of facilities			2,399	2,399

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 23 Odds Ratios for diagnosis of a case of pneumonia. Logistic, Logistic Fixed and Random Effects models.

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	0.131***	0.295***	0.564	0.264***
	(0.0244)	(0.0595)	(0.205)	(0.0598)
Nurse Officer	0.201***	0.442***	0.540**	0.390***
	(0.0300)	(0.0739)	(0.147)	(0.0733)
Nurse Midwife	0.170***	0.437***	0.591	0.387***
	(0.0346)	(0.0929)	(0.213)	(0.0949)
CHEW	0.105***	0.281***	0.322***	0.232***
	(0.0150)	(0.0432)	(0.0965)	(0.0411)
JCHEW	0.0877***	0.234***	0.285***	0.190***
	(0.0135)	(0.0383)	(0.0944)	(0.0359)
Env Hlth Off/Ass	0.110***	0.221***	0.187***	0.164***
	(0.0274)	(0.0563)	(0.0886)	(0.0490)
Comm Hlth Ass	0.0620***	0.208***	0.341*	0.171***
	(0.0181)	(0.0641)	(0.201)	(0.0578)
Hlth Att/AuxNurse	0.0487***	0.206***	0.287**	0.172***
	(0.0109)	(0.0474)	(0.148)	(0.0465)
Dent Off/Nur/Tch	0.0835***	0.192***	0.317**	0.158***
	(0.0298)	(0.0719)	(0.175)	(0.0674)
Female		0.590***	0.783*	0.573***
		(0.0435)	(0.108)	(0.0474)
Years of Experience		1.006*	1.010*	1.007*
		(0.00358)	(0.00566)	(0.00401)
Total non-ess Q		1.034***	1.036***	1.039***
		(0.00187)	(0.00412)	(0.00214)
Constant	5.986***	0.910		0.882
	(0.799)	(0.159)		(0.170)
Observations	5,059	4,957	2,141	4,957
Number of facilities			608	2,399

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 24: Odds Ratios for prescription of recommended antibiotics (amoxicillin or co-trimoxazole) for a case of pneumonia. Logistic, Logistic Fixed and Random Effects models.

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	2.444***	6.137***	1.135	3.774***
	(0.838)	(2.094)	(0.394)	(0.793)
Nurse Officer	1.806*	4.180***	1.420	3.084***
	(0.560)	(1.358)	(0.351)	(0.506)
Nurse Midwife	1.235	2.979***	0.916	3.190***
	(0.466)	(1.242)	(0.316)	(0.733)
CHEW	1.682*	4.847***	1.167	4.417***
	(0.506)	(1.535)	(0.328)	(0.680)
JCHEW	1.622	4.758***	1.229	4.960***
	(0.505)	(1.600)	(0.376)	(0.832)
Env Hlth Off/Ass	1.302	3.744***	0.999	4.389***
	(0.667)	(1.866)	(0.463)	(1.243)
Comm Hlth Ass	0.931	3.316***	0.658	2.963***
	(0.372)	(1.447)	(0.291)	(0.869)
Hlth Att/AuxNurse	0.652	2.376**	1.659	4.041***
	(0.230)	(0.980)	(0.641)	(0.942)
Dent Off/Nur/Tch	0.496	1.468	1.213	2.549**
	(0.282)	(0.784)	(0.677)	(0.998)
Female		0.755***	0.811	0.848**
		(0.0728)	(0.113)	(0.0705)
Years of Experience		1.000	0.993	0.996
		(0.00545)	(0.00513)	(0.00384)
Total non-ess Q		1.031***	1.024***	1.030***
		(0.00318)	(0.00360)	(0.00207)
Constant	1.118	0.179***		0.225***
	(0.325)	(0.0657)		(0.0405)
Observations	5,059	4,957	2,238	4,957
Number of facilities			644	2,399

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 25: Odds Ratios for prescription of any effective antibiotics for a case of pneumonia. Logistic, Logistic Fixed and Random Effects models.

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	2.448***	4.792***	1.035	3.351***
	(0.792)	(1.405)	(0.378)	(0.752)
Nurse Officer	2.124**	4.008***	1.695**	3.236***
	(0.625)	(1.105)	(0.438)	(0.563)
Nurse Midwife	1.473	2.815**	1.006	3.385***
	(0.595)	(1.159)	(0.364)	(0.841)
CHEW	1.793**	4.002***	1.049	3.799***
	(0.498)	(1.023)	(0.308)	(0.613)
JCHEW	1.588	3.536***	0.966	3.743***
	(0.466)	(0.986)	(0.308)	(0.658)
Env Hlth Off/Ass	1.541	3.352**	0.934	3.606***
	(0.871)	(1.789)	(0.444)	(1.099)
Comm Hlth Ass	1.103	3.092**	0.582	2.419***
	(0.451)	(1.394)	(0.275)	(0.754)
Hlth Att/AuxNurse	0.595	1.643	1.076	3.025***
	(0.203)	(0.600)	(0.449)	(0.744)
Dent Off/Nur/Tch	0.431	0.963	1.045	2.033*
	(0.241)	(0.483)	(0.599)	(0.843)
Female		0.737***	0.813	0.784***
		(0.0823)	(0.121)	(0.0713)
Years of Experience		0.999	0.995	0.997
		(0.00565)	(0.00559)	(0.00415)
Total non-ess Q		1.028***	1.026***	1.030***
		(0.00342)	(0.00376)	(0.00225)
Constant	1.378	0.332***		0.399***
	(0.366)	(0.107)		(0.0743)
Observations	5,103	4,996	2,046	4,996
Number of facilities			581	2,411

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 26: Odds Ratios for prescription of paracetamol for a case of pneumonia. Logistic, Logistic Fixed and Random Effects models.

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	1.716	4.659***	1.595	4.431***
	(0.631)	(1.703)	(0.569)	(0.955)
Nurse Officer	1.545	3.964***	1.807**	3.579***
	(0.457)	(1.274)	(0.471)	(0.602)
Nurse Midwife	1.981*	5.426***	1.903*	3.509***
	(0.816)	(2.367)	(0.660)	(0.816)
CHEW	1.724*	5.601***	2.211***	5.487***
	(0.508)	(1.777)	(0.640)	(0.874)
JCHEW	1.471	4.792***	2.248**	4.980***
	(0.447)	(1.565)	(0.708)	(0.853)
Env Hlth Off/Ass	1.287	4.166***	1.617	4.102***
	(0.635)	(1.993)	(0.730)	(1.167)
Comm Hlth Ass	1.209	4.865***	1.048	3.315***
	(0.469)	(2.234)	(0.501)	(0.989)
Hlth Att/AuxNurse	1.250	5.336***	1.560	3.909***
	(0.569)	(2.374)	(0.650)	(0.937)
Dent Off/Nur/Tch	1.076	3.955**	1.691	3.609***
	(0.699)	(2.272)	(1.028)	(1.473)
Female		0.757***	1.000	0.786***
		(0.0778)	(0.138)	(0.0665)
Years of Experience		0.999	1.004	0.997
		(0.00562)	(0.00536)	(0.00392)
Total non-ess Q		1.034***	1.031***	1.032***
		(0.00350)	(0.00385)	(0.00214)
Constant	1.085	0.146***		0.174***
	(0.309)	(0.0531)		(0.0323)
Observations	5,059	4,957	2,274	4,957
Number of facilities			647	2,399

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 27: Odds Ratios for recommendation of follow-up within two days time for a case of pneumonia. Logistic, Logistic Fixed and Random Effects models

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	1.690	4.899***	6.120***	7.322***
	(0.585)	(1.699)	(2.692)	(1.902)
Nurse Officer	1.011	2.017**	4.132***	2.993***
	(0.269)	(0.642)	(1.400)	(0.639)
Nurse Midwife	1.396	2.912**	3.318***	2.632***
	(0.700)	(1.512)	(1.530)	(0.786)
CHEW	1.048	3.038***	4.747***	4.645***
	(0.284)	(0.852)	(1.778)	(0.924)
JCHEW	1.101	3.445***	4.565***	4.976***
	(0.323)	(1.028)	(1.844)	(1.064)
Env Hlth Off/Ass	0.413**	1.295	2.027	3.748***
	(0.180)	(0.529)	(1.397)	(1.362)
Comm Hlth Ass	0.754	2.840**	4.782**	4.503***
	(0.367)	(1.405)	(3.295)	(1.819)
Hlth Att/AuxNurse	0.545	2.054	1.207	4.221***
	(0.250)	(1.098)	(0.714)	(1.338)
Dent Off/Nur/Tch	0.999	3.278**	4.546**	3.194**
	(0.577)	(1.762)	(3.023)	(1.656)
Female		1.433***	0.889	1.282**
		(0.186)	(0.154)	(0.132)
Years of Experience		0.995	0.998	0.997
		(0.00681)	(0.00702)	(0.00494)
Total non-ess Q		1.035***	1.038***	1.042***
		(0.00218)	(0.00438)	(0.00228)
Constant	0.238***	0.0184***		0.00783***
	(0.0628)	(0.00564)		(0.00203)
Observations	5,059	4,957	1,527	4,957
Number of facilities			414	2,399

Note: Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 28: Odds Ratios for prescription of full recommended treatment for a case of pneumonia. Logistic, Logistic Fixed and Random Effects models.

VARIABLES	(1) Logistic	(2) Logistic with health worker characteristics	(3) Logistic FE with health worker characteristics	(4) Logistic RE with health worker characteristics
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	1.542	6.277***	6.857***	9.928***
	(0.648)	(2.798)	(3.690)	(3.005)
Nurse Officer	1.084	2.892***	2.735**	3.586***
	(0.304)	(1.066)	(1.097)	(0.887)
Nurse Midwife	0.852	2.191	1.898	2.394**
	(0.431)	(1.455)	(1.071)	(0.896)
CHEW	0.971	3.846***	3.134**	5.884***
	(0.292)	(1.279)	(1.396)	(1.350)
JCHEW	0.917	3.873***	2.549*	6.391***
	(0.272)	(1.303)	(1.233)	(1.580)
Env Hlth Off/Ass	0.454	1.759	0.905	4.680***
	(0.222)	(0.824)	(0.756)	(1.967)
Comm Hlth Ass	0.215**	1.205	2.509	2.575
	(0.156)	(0.818)	(3.046)	(1.606)
Hlth Att/AuxNurse	0.348*	2.152	1.747	4.849***
	(0.192)	(1.372)	(1.302)	(2.002)
Dent Off/Nur/Tch	1.060	4.741***	4.528*	6.211***
	(0.632)	(2.528)	(3.517)	(3.538)
Female		1.183	0.966	1.051
		(0.198)	(0.207)	(0.127)
Years of Experience		0.990	0.995	0.996
		(0.00801)	(0.00869)	(0.00595)
Total non-ess Q		1.041***	1.049***	1.049***
		(0.00243)	(0.00549)	(0.00278)
Constant	0.158***	0.00776***		0.00255***
	(0.0465)	(0.00278)		(0.000816)
Observations	5,103	4,996	1,128	4,996
Number of facilities			295	2,411

Note: Full recommended treatment is defined as the prescription of recommended antibiotics (amoxicillin or co-trimoxazole) and paracetamol and follow-up within two days time. Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Annex V: Paper 3 additional figures and tables

Figure 14: Diabetes consultation questions by cadre

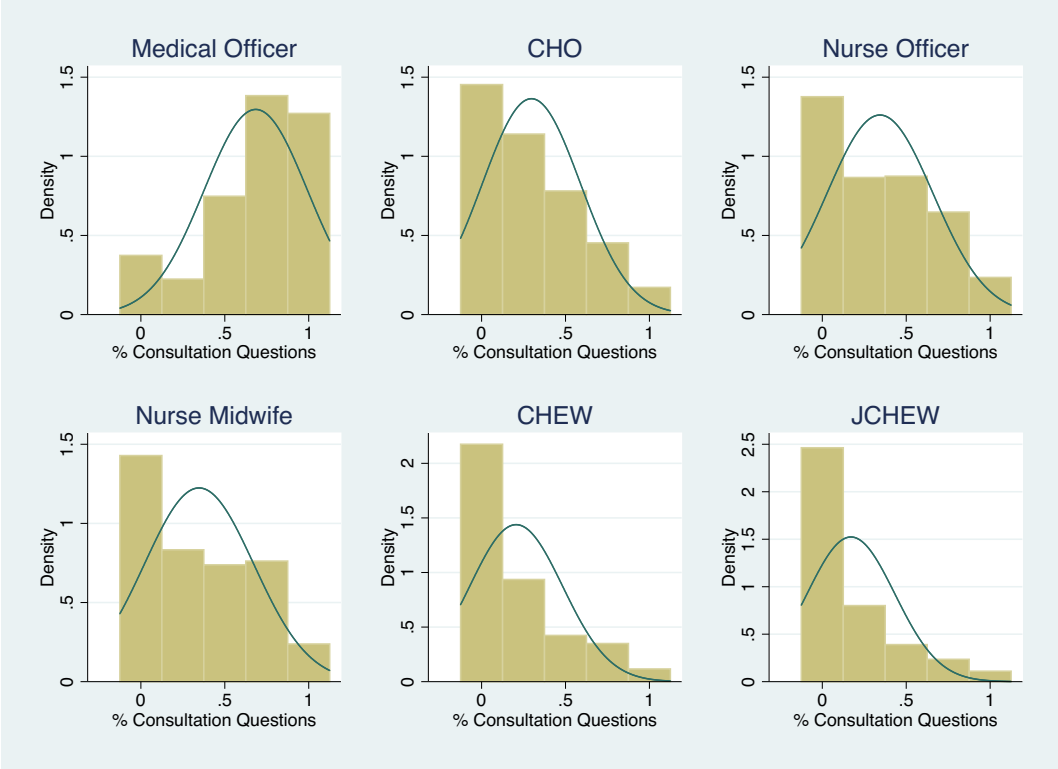


Table 29: Estimated Differences in Diabetes consultation process knowledge OLS, FE and RE models

VARIABLES	(1) OLS-Cadre	(2) OLS-Health Worker Characteristic	(3) Fixed Effects-Facility Characteristic	(4) Random Effects-Facility Characteristic
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	-0.355***	-0.174***	-0.133***	-0.152***
	(0.0561)	(0.0476)	(0.0466)	(0.0298)
Nurse Officer	-0.263***	-0.0839	-0.0563	-0.0912***
	(0.0620)	(0.0534)	(0.0428)	(0.0289)
Nurse Midwife	-0.315***	-0.129**	-0.0790	-0.0951***
	(0.0667)	(0.0546)	(0.0510)	(0.0349)
CHEW	-0.429***	-0.210***	-0.150***	-0.198***
	(0.0572)	(0.0491)	(0.0447)	(0.0273)
JCHEW	-0.476***	-0.243***	-0.168***	-0.224***
	(0.0583)	(0.0509)	(0.0451)	(0.0275)
Env Hlth Off/Ass	-0.486***	-0.237***	-0.158***	-0.208***
	(0.0667)	(0.0556)	(0.0552)	(0.0334)
Comm Hlth Ass	-0.509***	-0.228***	-0.183***	-0.220***
	(0.0652)	(0.0533)	(0.0527)	(0.0339)
Hlth Att/AuxNurse	-0.540***	-0.220***	-0.155***	-0.216***
	(0.0595)	(0.0525)	(0.0501)	(0.0297)
Dent Off/Nur/Tch	-0.434***	-0.205***	-0.166***	-0.215***
	(0.0800)	(0.0584)	(0.0558)	(0.0418)
Female		0.0174	-0.0120	-0.000765
		(0.0106)	(0.0137)	(0.00817)
Years of Experience		0.000434	0.000678	0.000518
		(0.000575)	(0.000609)	(0.000425)
Total non-ess Q		0.00768***	0.00806***	0.00804***
		(0.000241)	(0.000404)	(0.000185)
Constant	0.622***	0.129**	0.0898*	0.129***
	(0.0575)	(0.0549)	(0.0493)	(0.0292)
Observations	4,120	4,049	4,049	4,049
R-squared	0.120	0.421	0.270	
Number of facilities			2,089	2,089
Rho			0.4835	0.1836

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 30: Estimated Odds Ratios for Type II Diabetes Diagnostic Accuracy Logistic, Logistic FE and Logistic RE Models

VARIABLES	(1) Logistic-Cadre	(2) Logistic -Health Worker Characteristic	(3) Logistic Fixed Effects-Facility Characteristic	(4) Logistic Random Effects-Facility Characteristic
Medical Officer	[ref]	[ref]	[ref]	[ref]
CHO	0.299**	0.596	0.302*	0.156***
	(0.144)	(0.255)	(0.204)	(0.0634)
Nurse Officer	0.729	1.540	1.137	0.779
	(0.297)	(0.569)	(0.743)	(0.292)
Nurse Midwife	0.652	1.223	0.593	0.426**
	(0.282)	(0.459)	(0.417)	(0.179)
CHEW	0.213***	0.465**	0.326*	0.158***
	(0.0800)	(0.158)	(0.209)	(0.0569)
JCHEW	0.151***	0.350***	0.258**	0.110***
	(0.0599)	(0.130)	(0.172)	(0.0413)
Env Hlth Off/Ass	0.181***	0.503	0.226*	0.168***
	(0.0826)	(0.234)	(0.189)	(0.0810)
Comm Hlth Ass	0.0680***	0.190***	0.106**	0.0605***
	(0.0399)	(0.115)	(0.102)	(0.0360)
Hlth Att/AuxNurse	0.0411***	0.143***	0.0490***	0.0383***
	(0.0221)	(0.0752)	(0.0493)	(0.0214)
Dent Off/Nur/Tch	0.238*	0.558	0.164*	0.0857***
	(0.182)	(0.414)	(0.158)	(0.0573)
Female		1.575***	1.123	1.118
		(0.230)	(0.239)	(0.138)
Years of Experience		0.996	1.010	1.005
		(0.00555)	(0.00835)	(0.00580)
Total non-ess Q		1.047***	1.070***	1.057***
		(0.00326)	(0.00696)	(0.00350)
Constant	1.493	0.0957***		0.135***
	(0.550)	(0.0379)		(0.0530)
Observations	4,120	4,049	1,328	4,049
Number of facilities			375	2,089
Rho			0.4981[i]	0. .2047[i]

Note: Rho in models (3) and (4) was calculated using equally specified linear probability models. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Curriculum Vitae

MANUELA VILLAR URIBE

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Washington, DC, 20010
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SUMMARY

Health Systems specialist with over 9 years of experience working on health financing and quality of health service delivery in Latin America, Africa and Asia.

EDUCATION

August 2011-2015 *(Expected)*
PhD Baltimore, Maryland

Bloomberg School of Public Health,
Johns Hopkins University

- *International Health with a concentration on Health Systems.*
- *Thesis Topic: Task-shifting for primary care in Nigeria.*

September 2005- December 2006
Master of Public Health New Orleans, Louisiana

Tulane University School of Public Health and Tropical Medicine

- *International Health and Development with a concentration on Monitoring and Evaluation of Infectious Disease Programs.* Fall semester 2005 was spent as a full time student in the Harvard School of Public Health due to Hurricane Katrina.

September 2001-June 2005
Bachelor of Science Montreal, Canada

McGill University

- Double major in *Biology* and *International Development Studies.*

RESEARCH AND WORK EXPERIENCE

April 2015—June 2015
Consultant Washington, DC

Health, Nutrition and Population Global Practice
World Bank Group

- Commissioned to co-author an HNP Discussion Paper and 3 Policy Briefs documenting the experience of the SaluDerecho initiative, for the right to health, in Latin America. Research involved qualitative methods to discern the policy processes in the management of health-related litigation in selected countries across the region. Lessons seek to inform countries working towards Universal Health Coverage (UHC).

July 2014—May 2015
Consultant Washington, DC

Center for Global Development

- Commissioned to write a chapter on Data, Monitoring and Evaluation of Health Benefits Plans for a book on "How-to of Health Benefits: Options and Experiences on the Path to UHC in Low- and Middle-Income Countries". The chapter a presents a framework for designing monitoring and evaluation systems for countries who implement health benefits plans within the context of UHC.

June 2012—October 2014

Consultant—Health Specialist Nairobi, Kenya
Abuja, Nigeria
Maputo, Mozambique
Washington, DC

Human Development, Africa Region, World Bank Group

- Designed the Service Delivery Indicator Survey instrument to assess the quality of health service delivery in 15-20 countries in the sub-Saharan Africa region.
- Managed survey data collection in Kenya, Nigeria and Mozambique, including enumerator training, supervision and data entry.
- Analyzed survey data for publication.

February 2012—June 2013

Research Assistant Baltimore, Maryland
Phnom Penh, Cambodia

International Health Department,
Johns Hopkins Bloomberg School of Public Health

- Conducted qualitative analysis of data related to community health insurance and medical injection practices in Cambodia.
- Developed a behavior change communication intervention related to insurance and medical injection seeking, designed survey instrument for evaluation, managed data collection process and analyzed data for publication.

October 2012—December 2012

Teaching Assistant Baltimore, Maryland

Health Systems in Low and Middle Income Countries Course,
International Health Department,
Johns Hopkins Bloomberg School of Public Health

- Participated in curriculum development discussions, led group discussions in Health Financing modules, commented and graded group and individual student papers.

December 2008—August 2011

Extended Term Mexico City, Mexico
Consultant Bogotá, Colombia

Health Sector, Mexico Country Office,
Latin America and Caribbean Region, World Bank Group

- As Public Health Specialist in multi-sectorial teams, contributed to project design, supervision, analytical activities and government relations in Mexico and Colombia.
- Led Health System Separation of Functions research and supported state-level initiatives through analytical and advisory activities.
- Led the design and implementation of the human health component of a US$2millon Avian influenza preparedness project for Colombia.
- Led the design of technical components, monitoring and evaluation and implementation arrangements components in the preparation of the US$500millon emergency project for the prevention and control of influenza A/H1N1 in Mexico.
- Led technical support activities for the Mexican National Surveillance System strengthening.
- Contributed technical expertise in the preparation and supervision of US$1.25bn project for the expansion of Mexico's subsidized health insurance (*Seguro Popular*), including the design of technical components, monitoring and evaluation and implementation arrangements.

March 2009—April 2010

Consultant Madrid, Spain
Mexico City, Mexico

Fundación MAPFRE

- Co-authored a book on the role of the private sector on health insurance in Latin America and the possibilities of expanding this role to reach universal health insurance coverage in the Region. Used secondary data and a comprehensive literature review for a detailed analysis of the health systems of 18 Latin American Countries: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Uruguay and Venezuela.

December 2007 – December 2008

Consultant Washington, DC

Independent Evaluation Group, World Bank Group

- Led analysis of decade long monitoring and evaluation strategies within World Bank Health projects.
- As monitoring and evaluation specialist, contributed to the portfolio evaluation of all the Health, Nutrition and Population projects of the World Bank financed since 1997.
- Produced analytical notes on nutrition projects within the portfolio, corruption, health reform and health related analytic work.

November 2007 – June 2008

Consultant Washington, DC

Brookings Institution

- Co-authored a book chapter and peer-reviewed journal article on the impact of health insurance reform in Colombia.

May – September 2007

Technical Officer-Intern Washington, DC

Emergency Preparedness and Disaster Relief Unit,
Pan American Health Organization

- Monitored and communicated information on natural disasters in the Latin American and Caribbean region producing weekly reports on effects of disasters on the health systems of countries or affected areas.
- Gathered and analyzed data on previous disasters to produce information on lessons learned.
- Participated and conducted meetings and led communication with government officials and experts for field coordination of disaster response.

April – May 2007

Evaluation Officer-Intern Washington, DC

Sustainable Development Department,
Organization of American States

- Evaluated grant proposals of research projects focusing on malaria, dengue and chagas diseases in Latin America.
- Provided technical public health expertise to grantees for improved quality of research methods and data collection strategies.

February – December 2006

Program Analyst New Orleans, Louisiana

The Tulane University Payson Center for International Development and Technology Transfer

- Designed and managed delivery of web based distance education courses for the certificate program on HIV/AIDS of the School of Public Health at the National University of Rwanda.
- Supported project development in the areas of child survival, malaria, and nutritional access and quality for the Twubakane Health Decentralization Program.

Summer 2006

Program Coordinator Kigali, Rwanda

National University of Rwanda School of Public Health

- Coordinated the three-month USAID funded Certificate Training Program for HIV/AIDS and MPH program module.
- Conducted quantitative analysis of large household survey data sets for two CARE Rwanda managed, HIV/AIDS related project evaluations.
- Trained faculty members in the use of ArcGIS for project evaluation purposes.

Summer 2005

Research Assistant Boston, Massachusetts

Harvard School of Public Health

- Conducted laboratory based Tuberculosis vaccine research. Work in this project included literature review, experimental design, bacterial genetic design and cloning, bacterial growth monitoring and data analysis.

Summer 2004

Project Development Intern Bogotá, Colombia

Patio Bonito, Fundación Social

- Guided the development of a grassroots women's group future goals and strategies, creating a brochure to improve funding possibilities.
- Provided advice to local community groups, on project design and fund management, in an urban sustainable development project.

2003 - 2004

Researcher Montreal, Canada

McGill University Department of Biology

- Conducted laboratory based evolutionary biology research related to algal blooms. Work included all aspects of experimental design, through project completion, data analysis and report writing.

Summer 2003

Research Assistant Boston, Massachusetts

Harvard Medical School

- Conducted laboratory based cystic fibrosis research. Work included experimental design, bacterial and fungal growth monitoring and data analysis.

Summer 2002

Research Assistant Cambridge, Massachusetts

Harvard Department of Molecular and Cellular Biology

- Conducted laboratory based cancer related, cell cycle research. Work included experimental design, genetic design and cloning, bacterial and nematode growth monitoring, data analysis and report writing.

2000 - 2001
Research Assistant Cambridge, Massachusetts

Harvard Department of Organismal and Evolutionary Biology

- Conducted laboratory based research on effects of increased CO_2 on plant reproduction and growth. Work included experimental design, setup and monitoring, data collection, analysis, presentation and report writing.

HONORS AND AWARDS

- Received Johns Hopkins Bloomberg School of Public Health, ***Health Systems Program International Conference Travel Award*** to participate in the 2nd Global Symposium on Health Systems Research in Beijing, October 2012.
- Received ***James P. Grant Child Survival award*** for academic excellence and a high degree of potential for contributions to the goals of child survival. Awarded by the Tulane School of Public Health and Tropical Medicine, May 18th, 2007.
- Student ***graduation speaker*** for Tulane University School of Public Health and Tropical Medicine. December 15, 2006
- Elected as ***Senator for the Graduate and Professional Student Association*** (GAPSA) of Tulane University for 2006.
- Elected as ***International Student Representative*** for the Tulane University School of Public Health and Tropical Medicine, January 2006.

PUBLICATIONS

- Kurowski, C., and **Manuela Villar-Uribe**. 2012. "Mexico's Social Protection in Health and the Transformation of State Health Systems." World Bank, Washington, DC.
- Giedion, U., **Villar, M**. and Avila, A. 2010. "Los Sistemas de Salud en Latinoamérica y el papel del Seguro Privado". Instituto de Ciencias del Seguro: Fundación Mapfre. Madrid, España. Available at: http://www.mapfre.com/fundacion/es/publicaciones/ciencias-seguros/libros-cuadernos/los-sistemas-de-salud-en-latinoamerica-y-el-papel-del-seguro-privado.shtml
- Giedion, U., Alfonso EA. Diaz, BY., Flórez, CE., Pardo, R. and **Villar, M**. 2010. "Colombia's Big Bang Health Insurance Reform" in Escobar, ML., Griffin, C. and Shaw, P. *Impact of Health Insurance in Low and Middle Income Countries*. Brookings Institution Press. Baltimore, MD. USA.
- **Villar Uribe, M**. 2010. "Pilot projects and impact evaluations in the HNP lending portfolio: An assessment." IEG Working Paper. Independent Evaluation Group, World Bank, Washington, D.C.
- Giedion, U. and **Villar Uribe, M**. 2009. *Colombia's Universal Health Insurance System.* Health Affairs. 28(3):853-863.

Significant Contributions to:

- World Bank, African Economic Research Consortium and African Development Bank. 2014. *Education and Health Services in Nigeria: Data for Results and Accountability*. Service Delivery Indicators Initiative. IBRD, The World Bank.
- World Bank, African Economic Research Consortium and African Development Bank. 2013. *Education and Health Services in Kenya: Data for Results and Accountability*. Service Delivery Indicators Initiative. IBRD, The World Bank.
- Ribe, H., Robalino. D.A. and Walker, I. 2010. "Achieving Effective Social Protection for All in Latin America and the Caribbean: From Right to Reality. World Bank Group. Washington DC.
- World Bank. 2009. *Improving Effectiveness & Outcomes for the Poor in Health, Nutrition & Population: An Evaluation of World Bank Group Support since 1997*. The World Bank, Independent Evaluation Group Report. Washington DC.
- Thurman, T., Haas, L., Dushimana A. 2006. *CARE Rwanda's Case Management Program: Evaluation Report.* National University of Rwanda School of Public Health. Kigali, Rwanda.
- He J-S, Bazzaz FA. 2003. *Density-dependent responses of reproductive allocation to elevated atmospheric CO2 in Phytolacca americana*. New Phytologist, 157: 229-239.
- He J-S, Bazzaz FA, Schmid B. 2002. *Interactive effects of diversity, nutrients and elevated CO2 on experimental plant communities*. Oikos, 97: 337-348.

PRESENTATIONS

- November 11, 2012, Beijing, China. The challenges of universalizing health care: South Africa's health reform. Second Global Symposium on Health Systems Research.
- June 8, 2011, Santo Domingo, Dominican Republic. Keynote speaker: “The Role of Private Sector Health Insurance in Latin American Health Systems”. XIV International Congress of the Latin American Association of Private Health Systems (ALAMI).
- April 7, 2011, Buenos Aires, Argentina. “Private Health Insurance in Latin America and its role in Universal Health Insurance Coverage”. Fundación MAPFRE, Argentina.

LANGUAGES

- Spanish (Mother Tongue), English (Excellent), Portuguese (Advanced), French (Intermediate)